INDEPENDENT OFFICES APPROPRIATIONS FOR 1961

HEARINGS

BEFORE THE

SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS HOUSE OF REPRESENTATIVES

EIGHTY-SIXTH CONGRESS

SECOND SESSION

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PART 3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION NATIONAL SCIENCE FOUNDATION

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INDEPENDENT OFFICES APPROPRIATIONS FOR 1961

WEDNESDAY, MARCH 2, 1960.

NATIONAL SCIENCE FOUNDATION

WITNESSES

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Salaries and Expenses

Program and financing

	1959 actual	1960 estimate	1961 estimate
Program by activities:			
1. Support of science:			
(a) Grants and contracts	$65,608,390	$88,496,569	$116,055,000
(b) Program development, operation, and evaluation	1,700,120	2,400,000	2,565,000
2. Support of scientific manpower:			
(a) Grants and contracts	62,070,352	64,477,317	67,300,000
(b) Program development, operation, and evaluation	2,285,432	2,258,115	2,375,000
3. Executive direction and management	1,275,849	1,530,000	1,705,000
Total obligations	132,940,143	159,162,001	190,000,000
Financing:			
Unobligated balance brought forward	−1,329,144	−4,389,001	
Unobligated balance carried forward	4,389,001		
New obligational authority	136,000,000	154,773,000	190,000,000
New obligational authority:			
Appropriation	134,000,000	152,773,000	190,000,000
Transferred from "Operating expenses," Atomic Energy Commission (72 Stat. 881: 73 Stat. 363)	2,000,000	2,000,000	
Appropriation (adjusted)	136,000,000	154,773,000	190,000,000

Object classification

	1959 actual	1960 estimate	1961 estimate
NATIONAL SCIENCE FOUNDATION			
Total number of permanent positions	459	526	564
Full-time equivalent of all other positions	21	29	35
Average number of all employees	389	519	561
Number of employees at end of year	544	601	646
Average GS grade and salary	7.8 $6,443	8.2 $6,679	8.2 $6,688
Average salary of ungraded positions	$13,241	$13,605	$13,183
01 Personal services:			
Permanent positions	$2,589,266	$3,563,817	$3,846,500
Positions other than permanent	162,696	241,290	292,000
Other personal services	84,260	82,893	66,500
Total personal services	2,836,222	3,888,000	4,205,000
02 Travel	258,286	409,000	450,000
03 Transportation of things	14,118	31,200	28,000
04 Communication services	109,070	118,000	135,000
05 Rents and utility services	4,989	10,300	10,000
06 Printing and reproduction	83,302	91,800	101,000
07 Other contractual services	11,089,602	4,946,152	8,626,000
Services performed by other agencies	391,274	323,600	400,000
08 Supplies and materials	51,913	53,000	65,000
09 Equipment	143,249	100,000	95,000
11 Grants, subsidies, and contributions	117,898,847	146,320,052	175,875,000
15 Taxes and assessments	8,546	9,200	10,000
Total, National Science Foundation	132,884,418	156,291,314	190,000,000

Mr. Thomas. Gentlemen, will the committee please come to order.

General Statement

Doctor, do you have a statement which you want to make on the budget?

Dr. Waterman. I have a statement for the record, Mr. Chairman.

Mr. Thomas. We shall insert your statement into the record at this point.

(The statement referred to follows:)

Mr. Chairman and members of the committee, the state of American science and technology continues to share the limelight of public attention with pressing economic and political problems of national concern. It is vital that this interest call forth a satisfactory response by the Federal Government. On this point, it is significant to note that funds for the performance of research and development in the United States in 1959–60 are expected to be about 2½ times the expenditures during 1953–54; $5.15 billion in 1953–54 as compared to an estimated $12.43 billion in fiscal year 1959–60. As a proportion of the gross national product, expenditures for research and development have also increased substantially. In 1953–54, 1.4 percent of a gross national product of $365 billion was expended for research and development and it is estimated that in 1959–60, 2.6 percent of a gross national product of $480 billion will be expended for research and development. The Federal Government as a fund source is the major contributor to this increase. As a rough estimate, about 60 percent of the $12.43 billion estimated national research and development expenditures for 1959–60, $7.45 billion, will be from Federal Government sources, largely for defense purposes. This is $4.7 billion increase over the $2.74 billion expended in 1953–54 for research and development by the Federal Government.

As an approximation about 8 percent of the estimated $12.43 billion total 1959–60 research and development expenditures of nearly $1 billion may be for basic research, of which about half will be from Federal fund sources. These approximations illustrate the growth and the order of magnitude of the Nation's research and development effort. The continued productivity and growth of an effort of this magnitude can be sustained only by an increasing availability of highly trained scientific and technical manpower and an expanding base of fundamental scientific knowledge. It is primarily in these two areas that the National Science Foundation contributes to the total national scientic and technological effort.

Experience has demonstrated that dependence entirely or even chiefly upon private and corporate initiative will not come close to providing the financial resources for the scientific and technological accomplishments of which we are capable and which are necessary to maintain the necessary strength in world competition. Therefore, a strong sustained Federal financial support program is and probably will continue to be vital to our future development.

As an important part of a total Federal Government effort for the support of science, the National Science Foundation has proposed in the budget document before you a wide range of programs which are regarded as highly important to the future national scientific potential of the United States and to the country's technological progress in the years to come. In developing these proposed programs for your consideration, the Foundation has relied heavily on the advice of the various scientific advisory bodies which provide guidance in the administration of the Foundation's statutory responsibilities. The budget which has been submitted for the fiscal year 1961 represents the combined judgment of the Foundation staff and the members of the National Science Board after taking all factors into consideration.

These programs are directed to increasing our national scientific effort by such means as (1) supporting a broad spectrum of basic scientific research through grants for research by individual scientists or groups of scientists made primarily to institutions of higher learning, (2) providing for essential highly specialized research facilities, which would not otherwise be available, primarily for use as basic research tools by the scientists in our institutions of higher learning, (3) improvement, where badly needed, of graduate research laboratories, (4) improving the quantity and quality of our scientific manpower, (5) strengthening science education, (6) providing means for more rapid and effective dissemination of scientific information, and (7) supporting cooperative enterprises with other countries, such as in post-IGY activities, notably in the Antarctic.

The fiscal year 1961 budget estimate totals $190 million for the regular salaries and expenses appropriation, an increase of $30,837,999 over the amount available for obligation in fiscal year 1960. There is also proposed a new foreign currency appropriation in the amount of $1,600,000 to continue support of certain foreign scientific information activities which were initiated with funds appropriated to the President in fiscal year 1959.

SUPPORT OF BASIC RESEARCH

It is estimated that total basic research proposal receipts will total $190 million for fiscal year 1961, an increase of $33 million over the receipts for

fiscal year 1960. The $78,800,000 estimated for the support of basic research grants and contracts will provide support for 37.5 percent of the estimated fiscal year 1961 proposal receipts.

In projecting the estimated research proposal reecipts, provision has been made for an increase in indirect cost allowances. Figures developed by the Foundation indicated that there was a substantial spread between the 15-percent rate allowed by the Foundation and the actual cost to the institutions. Because of the adverse effect which absorption of these costs was having on both the ability of the institutions to carry on research work and the maintenance of balanced and vigorous educational programs, the Foundation, effective January 1, 1960, authorized institutions to request up to 20 percent of total direct costs as the allowance for overhead in research proposals.

The cost of conducting basic research is increasing from year to year and is a factor which must be considered in our request for increased funds. Salaries are higher, modern equipment is more expensive, and the cost of supplies, travel, and other expenses related to research projects continue to increase. As an indication of the rate at which the cost of conducting basic research has increased, the value of the average research grant in fiscal year 1958 was $17,200 with an average duration of 2.09 years, and in fiscal year 1959 the average value had risen to $25,900, with an average duration of 2.26 years. It is estimated, based on actual experience through September 1959, that the average research grant in fiscal year 1960 will be about $30,500. The amount will probably increase to about $34,500 in fiscal year 1961. During the same fiscal year 1958 to fiscal year 1961 period the average value of the research proposals received will increase from $34,700 in fiscal year 1958 to an estimated $45,000 in fiscal year 1960 and to $50,000 in fiscal year 1961.

Another factor which affects the need for larger research appropriations is the increasing number of requests for renewed support. While renewal requests are carefully reviewed in competition with all of the proposals received, they are usually granted continued support because of the established scientific value of the research that has been and will be conducted. As a consequence, without an increase in funds, the Foundation is not able to support adequately research proposals from investigators who have not previously applied. About 75 to 85 percent of the amount requested for research proposal renewals is usually granted, whereas about 50 to 60 percent of the amounts requested for initial research proposals is awarded.

Two special items deserve mention, the $5,500,000 requested for the Antarctic program will provide $4 million for the continued operation of a basic four-station scientific program plus $1,500,000 for the conversion of an ice working ship for research along the Antarctic coasts, particularly in the underdeveloped field of oceanography. In the weather modification program, the $2 million requested will support studies of the fundamental processes involved in the development of clouds and the precipitation mechanisms.

SUPPORT OF BASIC RESEARCH FACILITIES

The fiscal year 1961 budget estimate of $29,550,000 for grants and contracts for basic research facilities is an increase of $16,750,000 or 131 percent over the fiscal year 1960 level. The various programs under this heading are summarized as follows:

Development of Graduate Research Laboratories.—$15 million or approximately 50 percent of the total basic research facilities program for fiscal year 1961 is for the purpose of assisting colleges and universities in developing and improving their graduate research laboratories. The need for such support is based on the fact that: (1) a large proportion of graduate level research laboratories in the Nation's universities and colleges are rapidly becoming obsolescent and (2) the financial resources of colleges and universities are strained to the utmost in carrying out their institutional responsibilities for instruction, principally at the undergraduate level; thus, adequate financial support for modern well-equipped graduate level laboratories is not now available to these institutions.

Under this program, participating institutions generally would be required to match Foundation grants on a dollar for dollar basis. The graduate research laboratories improved or developed with these funds are for use of faculty members or research associates in the pursuit of scientific research programs or of graduate and postdoctoral students for thesis or independent research.

Biological and medical sciences research facilities.—The fiscal year 1961 budget request for this program totals $3 million. The facilities provided under

this program are specialized, either in the kind of research for which they are used or because of the significance of their locations. They are usually used on a regional basis, and the costs are generally of such magnitude that they cannot be financed from the resources of the institutions.

Mathematical, physical and engineering sciences research facilities.—The estimate for this category totals $11,550,000, or approximately 40 percent of the overall fiscal year 1961 basic research facilities program. Funds budgeted for this category of facilities will be utilized to support a wide range of high-cost specialized research activities in the following areas:

Two million dollars for the acquisition of high-speed computers of advanced design at universities for use in basic research.

Two million seven hundred and fifty thousand dollars is requested for the construction of a second modern 175-foot oceanographic vessel to provide a long-range, all-season, and all-latitudes base of operations for scientific research in oceanography and allied sciences.

One million five hundred thousand dollars is requested to support the acquisition of facilities and equipment needed for modern research in the atmospheric sciences. The Foundation proposes to: (1) provide support for the operation of a central organization to stimulate, plan and coordinate a program of cooperative research among university groups; and (2) support improved research facilities which will be used cooperatively by university research groups and by the central organization.

Three million dollars is requested for continued support of the National Radio Astronomy Observatory, a federally owned research facility located at Green Bank, Va. Fiscal year 1961 requirements are projected on the basis of nearly full-scale operations upon completion of the major research instruments authorized to date, and for the construction of additional technical facilities necessary to develop more fully the scientific capabilities of the Observatory.

Two million dollars is requested for continued support of the Kitt Peak National Observatory, a federally owned resarch facility located near Tucson, Ariz. The fiscal year 1961 request is $1,100,000 more than the fiscal year 1960 program of $900,000. The principal factors contributing to the increased request are—

(1) introduction of a new program for the design of an advanced optical research telescope;

(2) support for a nearly full-scale research program for presently scheduled research facilities; and,

(3) provision for additional building and site improvements required to improve the research capability of the Observatory.

Three hundred thousand dollars is requested for the development of detailed planning and engineering studies related to the establishment of a geophysical institute in Hawaii. These studies will provide the bases for determining the scope of scientific research desirable at such an institute, and the facilities necessary for the conduct of such research.

Need for Federal support of basic research facilities.—The National Science Foundation has a major responsibility to assist research institutions in securing the facilities necessary for the conduct of basic research. These institutions cannot provide the financial resources now necessary to acquire costly research facilities, instruments and equipment.

Colleges and universities are a major source of basic scientific research. Approximately 90 percent of National Science Foundation research grants are being made to investigators at colleges and universities. The requirements for basic research facilities must compete with the financial requirements necessary to support the broad educational objectives of colleges and universities. Institutions of higher learning, in general, are faced with the necessity for a major expansion of educational facilities in order to meet the challenge of doubled enrollments over the next 10 to 15 years. Thus, these educational institutions are not able to provide adequate financial support for scientific research facilities when faced with the larger problem of providing financial support for their strictly educational requirements.

Another important source of basic research is in the independent scientific institutions not affiliated with a college or university. These institutions also have major financial problems. Endowments and other contributions are their primary sources of income. These institutions are constantly faced with the problem of rising costs and limited income. Obsolescence and deterioration of facilities have greatly impaired their effectivenes and no improvement in this situation can be expected without additional financial assistance.

The problem of adequate research facilities is compounded by the fact that new and important areas of scientific inquiry are constantly being developed, which require costly facilities and equipment.

DISSEMINATION OF SCIENTIFIC INFORMATION

The fiscal year 1961 request for $7,335,000 is about 36 percent above the fiscal year 1960 level of $5,391,531. The increase reflects, overall, both the growth of requirements to be met by Foundation support and the Foundation's effort to exercise the role of national leadership in the dissemination of scientific information assigned by congressional and executive directives.

The need for improving methods for compiling, storing, retrieving, and disseminating scientific information, is one of the most serious problems impeding our scientific effort today. Scientific progress is a step-by-step process which depends on the published record of previous scientific work. The great mass of unpublished scientific data and of published data that for one reason or another is not readily available to the working scientist, is at present a serious handicap. The Congress recognized the seriousness of this situation in the National Defense Education Act of 1958 by directing the Foundation to establish a Science Information Service and to "Provide for, or arrange for the provision of indexing, abstracting, translating, and other services leading to a more effective dissemination of scientific information, and undertake programs to develop new or improved methods, including mechanized systems, for making scientific information available." The program proposed for 1961 is designed to accelerate the Foundation's programs to accomplish more adequately the responsibility for the Science Information Service functions assigned by the National Defense Education Act.

SUPPORT OF SCIENTIFIC MANPOWER

The level of support provided for scientific manpower programs during fiscal years 1959 and 1960 would remain approximately the same during fiscal year 1961, the slight increase being to provide for increased costs. Of the approximately $2.9 million increase ($69.6 million in fiscal year 1961 compared to $66.7 million in fiscal year 1960), $2.4 million is required to cover anticipated increased costs (travel, tuition, dependency allowance, equipment allowance, indirect costs, and operating costs), $400,000 is attributed to modest program expansion, and approximately $100,000 is for increased administrative expenses.

Over two-thirds of the support of scientific manpower estimate for fiscal year 1961 covers two major areas of program activity, namely, institutes (50.3 percent), and fellowships (20.1 percent). Three other programs (special projects in science education, course content improvement, and science education and personnel studies), plus support for program development, operation and evaluation account for the remaining 30 percent. The funds requested for increased program requirements ($400,000) would be used for a moderate expansion of the institutes and special projects in science education programs.

Significant and substantial progress has been made by the National Science Foundation in finding ways to meet the mounting problems of education in the sciences. Working in close cooperation with the scientific and educational communities, and maintaining liaison with the Office of Education, the Foundation has developed and established techniques and approaches, some of which have already proved their effectiveness and others which show great promise. Others are still in the exploratory stages and with minor refinements may take their places among future established programs as funds become available.

The Foundation's present task is threefold:

(1) To continue these established programs at effective levels to help meet the growing need for improved education and training in the sciences within available funds.

(2) To continue to search for new approaches to problems which are as yet unsolved.

(3) To encourage increased efforts at all levels to improve opportunities for and the quality of education in the sciences.

SURVEYS AND REPORTS

The amount proposed for fiscal year 1961 will provide the same level of support as available in fiscal year 1960 and includes funds for statistical surveys and special studies made by the Foundation.

National Science Foundation program operation and management costs.—The amount proposed for fiscal year 1961 ($6,645,000) under this heading covers all the operating and management expenses of the Foundation. This amount represents an increase of about $457,000 over the amount ($6,188,115) available in fiscal year 1960. In relation to the total budget for the Foundation, the amount is 3.5 percent of the total Foundation request for fiscal year 1961. This percentage is to be compared with the figure of 3.9 percent for fiscal year 1960.

It is estimated that an average employment of 526 in fiscal year 1961 will be required to enable the Foundation to administer its various programs and activities in achieving its planned program objectives. The average employment for fiscal year 1961 represents an increase of 36 over fiscal year 1960. As a percentage of total Foundation funds, personal services will decrease from a rate of 2.4 percent in fiscal year 1960 to 2.2 percent in fiscal year 1961.

Mr. THOMAS. Dr. Waterman, you may proceed to highlight your statement.

Dr. WATERMAN. Thank you.

The overall program budget request estimate of the Foundation for 1961 amounts to $190 million. This is divided among the following major components: The support of science, which includes the support of basic research by grants; the support of basic research facilities; surveys and reports; dissemination of scientific information, and the associated administrative costs. In 1961, this budget item comes to $118,620,000, which is an increase of $30,594,118 over the estimate for 1960.

SUPPORT OF SCIENTIFIC MANPOWER

For the "Support of scientific manpower," which includes fellowships, the institute programs and special projects in science education, course content improvement, science education and personnel studies and the associated administrative costs totals $69,675,000 for 1961, which is an increase of $2,939,568. This represents holding the level just about as it is. The additional amount is mainly for increased costs associated with the programs for the coming fiscal year.

For "Executive direction and management of the Foundation," there is the sum of $1,705,000. The total for all components is $190 million.

BASIC RESEARCH GRANTS

In the "Support of basic research," Mr. Chairman, the $78,800,000 is intended, according to our estimates which have been quite reliable in the past, to cover 37.5 percent of the total money requested of the Foundation for basic research proposals.

BASIC RESEARCH FACILITIES

The sum for "Basic research facilities," namely, $29,550,000, represents an increase of $16,750,000. The major increase here is an increase in the item for the development of graduate research laboratories. The committee will recall that in our 1960 budget——

Mr. THOMAS. You started that program last year with about $2 million; did you not?

Dr. WATERMAN. Yes, sir. It now goes up to $15 million to cover a much more appreciable proportion of the needs primarily on the part of universities and college graduate research laboratories which

are badly in need of renovation and improvement. This is the larger item, then, in this increase for basic research facilities.

The rest of this goes to "Capital facilities," with which you are familiar, such as the Kitt Peak Observatory, the National Radio Astronomy Observatory, the computing program, an oceanographic research vessel and also a new item of $300,000 to get started on the Hawaiian Geophysical Institute. This last item was one which you may recall about 2 years ago on which there was a congressional resolution asking the Foundation to study the need for such an institute and to report on it. We appointed a special committee for that purpose, and in their report they made a strong recommendation that this be undertaken, but we have been unable to get started on it until now partly because it was our opinion at the Foundation that the University of Hawaii with which this would be associated should strtngthen its scientific and mathematics department before the Institute got underway. This they have done, we feel.

Mr. THOMAS. Why was this particular place picked for this purpose?

Dr. WATERMAN. Because the Central Pacific is a very important area to the United States and to have an institute in that neighborhood, taking full advantage of the marine life in the Pacific and to be associated with the university center there, is really a unique thing to do. Dr. Revelle, I am sure, can talk further to this point, but we feel this would be very desirable and the geophysicists agree that this would be desirable. We have nothing comparable in the Pacific, except the Scripps Institute on the west coast, but nothing out in the center of the area.

Mr. THOMAS. When you say "except" you are making quite a large exception; are you not?

Dr. WATERMAN. I stand corrected. There is nothing comparable in the center of the Pacific to this. The west coast is a long way off, of course.

Those represent the major items under the basic research facilities.

SURVEYS AND REPORTS

As for the "Surveys and reports," I believe the committee is familiar with these. We have a number of them and they are in very capable hands. This item remains just about the same in the budget.

I would like to call your attention to the fact that these are being looked at with a great deal of interest by Government, by industry and by universities. Since we now have the method of collecting this in a systematic fashion, we can establish trends, which is especially valuable.

DISSEMINATION OF SCIENTIFIC INFORMATION

The item under the "Support of science" activity for dissemination of scientific information is $7,335,000, which represents an increase of about one-third; or $1,943,469.

This is to enable us to discharge our responsibility which we have been given both by the Congress under the National Defense Education Act and also by Executive order of the President. In this, the Foundation is expected to take the leadership and serve as a central

focus for problems relating to exchange and dissemination of scientific information. The problem is getting larger all the time in dealing both with other governmental agencies and private establishments that work in this field. In this we expect the other Federal agencies to play their appropriate part and for that purpose Dr. Adkinson, in charge of this program, chairs an interagency group of people responsible in each agency for this field. In this way the Federal agencies can keep in touch and have their work fully coordinated.

Then, in accordance with the National Defense Education Act title, there is a Scientific Information Council, which is a statutory body set up by the Foundation. It gives advice with respect to this broad area.

PROGRAM DEVELOPMENT, OPERATION, AND EVALUATION

The final item in the support of science is $2,565,000 which covers the cost of program development, operation, and evaluation, making a total item of $118,620,000, as I said.

SUPPORT OF SCIENTIFIC MANPOWER

The budget item support of scientific manpower remains, as I said before, practically at the same level as in previous years but allows for extra costs which now appear in some of the items.

For example, for our fellowship programs we have the sum of $14 million, which represents an increase of $900,000 only. For our institute program we have the sum of $35 million, which represents an increase of $1,750,000. For special projects, in science education, there is the sum of $11.3 million which represents an increase of $128,600. Then, there is course content improvement, $6 million, the same as it was last year. For science education and personnel studies, $1 million, practically the same amount as last year. The increase is $44,083. For the cost of administering these programs; that is, for program development, operation and evaluation, $2,375,000, which represents an increase of $116,885.

The total cost for the support of scientific manpower in this estimate is $69,675,000, an increase of $2,939,568.

EXECUTIVE DIRECTION AND MANAGEMENT

Then for executive direction and management of the Foundation—these are additional administrative costs over and above the program development, operation and evaluation under the items I have mentioned earlier—the amount is $1,705,000, an increase of $175,000.

The allocations to other Government agencies, as I said, are none for the coming year.

Mr. THOMAS. Doctor, that is a good, quick summary.

SUMMARY OF BUDGET ESTIMATES

We shall insert into the record at this point pages 2, 4, 5, 6, together with the other objects which appear on page 7, a portion of page 8 and page 9 of the justifications.

(The pages referred to follow:)

Statement relating fiscal year 1959, fiscal year 1960, and fiscal year 1961 programs

[In thousands]

Fiscal year 1959 program (obligations incurred)	$132,940
Increase of grants and contracts in support of science	+22,888
Increase of grants and contracts in support of sicentific manpower	+2,407
Other increases (program development, operation and evaluation, and executive direction and management)	+927
Fiscal year 1960 program (obligations incurred)	159,162
Increase of grants and contracts in support of science	+27,558
Increase of grants and contracts in support of scientific manpower	+2,823
Other increases (program development, operation and evaluation, and executive direction and management)	+457
Fiscal year 1961 program (obligations incurred)	190,000

Analysis by activities

[In thousands]

	1959	Decrease	Increase	1960	Decrease	Increase	1961
Support of science	$67,308		$23,589	$90,897		$27,723	$118,620
Support of scientific manpower	64,356		2,379	66,735		2,940	69,675
Executive direction and management	1,276		254	1,530		175	1,705
Total obligations	132,940	0	26,222	159,162	0	30,838	190,000

Summary of budget estimate fiscal year 1961

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
Support of science:				
Basic research	$45,950,159	$67,067,116	$78,800,000	+$11,732,884
Basic research facilities	15,524,725	12,800,000	29,550,000	+16,750,000
Surveys and reports	230,254	367,235	370,000	+2,765
Dissemination of scientific information	3,847,527	5,391,531	7,335,000	+1,943,469
Program development, operation and evaluation	1,700,120	2,400,000	2,565,000	+165,000
Subtotal	67,252,785	88,025,882	118,620,000	+30,594,118
Support of scientific manpower:				
Fellowships	13,070,838	13,100,000	14,000,000	+900,000
Institutes	33,247,999	33,250,000	35,000,000	+1,750,000
Special projects in science education	8,940,905	11,171,400	11,300,000	+128,600
Course content improvement	6,030,325	6,000,000	6,000,000	0
Science education and personnel standards	780,285	955,917	1,000,000	+44,083
Program development, operation and evaluation	2,285,432	2,258,115	2,375,000	+116,885
Subtotal	64,355,784	66,735,432	69,675,000	+2,939,568
Executive direction and management	1,275,849	1,530,000	1,705,000	+175,000
Subtotal, NSF	132,884,418	156,291,314	190,000,000	+33,708,686
Allocations to other Government agencies	55,725	2,870,687	0	−2,870,687
Total	132,940,143	159,162,001	190,000,000	+30,837,999

The fiscal year 1961 budget estimate totals $190 million or $30,837,999 more than was available in fiscal year 1960. The summary explanation of this budget estimate is as follows:

A. Basic research grants and contracts

It is estimated that total basic research proposal receipts will total $190 million for fiscal year 1961; an increase of $33 million over the receipts for fiscal year 1960. The $78,800,000 estimated for the support of basic research grants and contracts will provide support for 37.5 percent of the estimated fiscal year 1961 proposal receipts.

In projecting the estimated research proposal receipts, provision has been made for an increase in indirect cost allowances. Because of rising costs of administration and the adverse effect of such increases upon the ability of institutions to carry on research work, the Foundation, effective January 1, 1960, authorized institutions to request up to 20 percent of total direct costs as the allowance for indirect costs in research proposals.

Also included under this heading are the following items:

(1) $2 million for continued support of the weather modification program; and

(2) $5.5 million for the Antarctic program.

B. Basic research facilities

An amount of $29,550,000, or 15.6 percent of the $190 million total, is estimated for basic research facilities, including $15 million for the development of graduate research laboratories. The remaining $14,550,000 provides $12,750,000 for established research facilities programs including university computing facilities, an oceanographic vessel, specialized biological and medical science facilities, and support for the national observatories at Green Bank, W.Va., and Tucson, Ariz. The $1.8 million will provide for new facilities:

(1) $0.3 million for the Hawaiian Geophysical Institute; and

(2) $1.5 million for atmospheric sciences facilities.

C. Other programs

An amount of $7,705,000 is estimated for the other two programs in the support of science activity: $370,000 for surveys and reports; and, $7,335,000 for dissemination of scientific information. There is an increase of about $2 million over the fiscal year 1960 level for the dissemination of scientific information activities to carry forward the program for improving the availability of foreign science information and unpublished research reports and for the support of American scientific publications. This program expansion is necessary to implement additional responsibilities assigned to the National Science Foundation by the National Defense Education Act of 1958. In addition, Executive Order 10807 directed the Foundation to provide leadership in the effective coordination of the scientific information activities of the Federal Government with a view to improving the availability and dissemination of scientific information.

D. Support of scientific manpower

An amount of $67.3 million is estimated for programs in support of scientific manpower. This amount represents an increase of about $2.8 million above the fiscal year 1960 level and will provide for—

(1) Increased costs such as travel, tuition, dependency allowances, and indirect costs for institutions which total about $2.4 million; and

(2) The remainder of the $2.8 million increase, $400,000, is for nominal program expansions in Institutes and in special projects in science education.

E. Program development, operation, evaluation, and executive direction and management

An amount of $6,645,000 is estmiated for all operating expenses of the Foundation in fiscal year 1961 including all costs of administering the programs of the Foundation such as salary costs of all personnel and all other miscellaneous expenses. This amount represents an overall increase in operating costs of $456,885 over the fiscal year 1960 level. This amount will provide for an increase of 35.1 in average employment over fiscal year 1960 and is considered necessary for effective management of the expanding programs and increasing focal agency responsibilities of the Foundation. The amount requested for administering the Foundation programs represents 3.5 percent of the total Foundation estimate of $190 million for fiscal year 1961.

The following table provides a distribution by object classification of the total operating expenses of the Foundation:

Summary of obligations by object

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
National Science Foundation:				
Average employment	367.8	490.9	526.0	+35.1
Average salary	$7,370	$7,551	$7,553	+$2
01 Personal services	$2,836,222	$3,888,000	$4,205,000	+$317,000
Staff	(2,710,739)	(3,707,000)	(3,973,000)	(+266,000)
Consultant, Divisional Committee Panels and National Science Board	(125,483)	(181,000)	(232,000)	(+51,000)
02 Travel	253,286	400,000	450,000	+50,000
03 Transportation of things	14,118	31,200	28,000	−3,200
04 Communication services	109,070	118,000	135,000	+17,000
05 Rents and utility services	4,989	10,300	10,000	−300
06 Printing and reproduction	83,302	91,800	101,000	+9,200
07 Other contractual services	11,480,876	5,269,752	9,026,000	+3,756,248
Administrative contracts	(1,466,039)	(1,217,700)	(1,266,000)	(+48,300)
Security investigations	(78,780)	(48,600)	(28,000)	(−20,600)
Employee life insurance	(7,758)	(10,300)	(11,000)	(+700)
Employee health benefits	0	0	(28,000)	(+28,000)
Program contracts	(9,928,299)	(3,993,152)	(7,693,000)	(+3,699,848)
08 Supplies and materials	51,913	53,000	65,000	+12,000
09 Equipment	143,249	100,000	95,000	−5,000
11 Grants, subsidies, and contributions	117,898,847	146,320,062	175,875,000	+29,554,938
Program grants	(117,677,455)	(146,110,047)	(175,662,000)	(+29,551,953)
Retirement fund	(145,311)	(200,900)	(213,000)	(+12,100)
Other	(76,081)	(9,115)	0	(−9,115)
15 Taxes and assessments	8,546	9,200	10,000	+800
Total, National Science Foundation	132,884,418	156,291,314	190,000,000	+33,708,686
ALLOCATIONS				
Department of the Army	14,313	22,099	0	−22,099
Bureau of Public Roads	41,412	2,848,588	0	−2,848,588
Total, allocations	55,725	2,870,687	0	−2,870,687
Total	132,940,143	159,162,001	190,000,000	+30,837,999

PROGRAM DEVELOPMENT, OPERATION, EVALUATION AND EXECUTIVE DIRECTION AND MANAGEMENT

Summary of obligations by object

		Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
	Average employment	367.8	490.9	526.0	+35.1
	Average salary	$7,370	$7,551	$7,552	+$2
01	Personal services	$2,836,222	$3,888,000	$4,205,000	+$317,000
	Staff	(2,710,739)	(3,707,000)	(3,973,000)	(+266,000)
	Consultant, Divisional Committee Panels, National Science Board	(125,483)	(181,000)	(232,000)	(+51,000)
02	Travel	253,286	400,000	450,000	+50,000
	Staff	(133,608)	(230,000)	(271,500)	(+41,500)
	Consultant, Divisional Committee, Panels, National Science Board	(119,678)	(170,000)	(178,500)	(+8,500)
03	Transportation of things	14,118	31,200	28,000	−3,200
04	Communication services	109,070	118,000	135,000	+17,000
05	Rents and utility services	4,989	10,300	10,000	−300
06	Printing and reproduction	83,302	91,800	101,000	+9,200
07	Other contractual services	1,535,314	1,276,600	1,333,000	+56,400
	Administrative contracts	(1,448,776)	(1,217,700)	(1,266,000)	(+48,300)
	Security investigations	(78,780)	(48,600)	(28,000)	(−20,600)
	Employee life insurance	(7,758)	(10,300)	(11,000)	(+700)
	Employee health benefits	0	0	(28,000)	(+28,000)
08	Supplies and materials	51,913	53,000	65,000	+12,000
09	Equipment	143,249	100,000	95,000	−5,000
11	Grants, subsidies, and contributions	221,392	210,015	213,000	+2,985
	Contributions to retirement fund	(145,311)	(200,900)	(213,000)	(+12,100)
	Other	(76,081)	(9,115)	0	(−9,115)
15	Taxes and assessments	8,546	9,200	10,000	+800
	Total	5,261,401	6,188,115	6,645,000	+456,885

Mr. THOMAS. This chart shows a breakdown of your budget for 1959, 1960, and 1961; does it not?

Dr. WATERMAN. Yes, sir; that is on page 12.

Mr. THOMAS. How long have you been in existence now?

Dr. WATERMAN. Well, our act was passed in 1950 and our operations began in late 1951, Mr. Chairman.

Mr. THOMAS. This is your ninth year of operation?

Dr. WATERMAN. Yes, sir; and the 10th year since the establishment of the National Science Foundation.

INCREASES OVER 1960

Mr. THOMAS. You had $132,940,143 for 1959 and it goes up to $159,162,001 for 1960 and then goes up to $190 million for 1961, an increase of $30,837,999 over 1960.

Your "Other objects" here such as "Travel" show an increase of $50,000. In other words, you go from $400,000 as of last year to $450,000 in 1961.

Your "Communications services" go from $118,000 to $135,000.

Why the sizable increase in communications services?

Dr. WATERMAN. Mr. Luton can answer that.

Mr. LUTON. That is primarily because of increases in staff, Mr. Chairman, which requires us to have additional monthly service charges and it also is to some extent due to increases in long-distance charges.

Mr. THOMAS. Does it have any connection with your dissemination centers and so forth?

Mr. LUTON. No, sir.

TOTAL EMPLOYMENT

Mr. THOMAS. What is your total employment for this year as against last year?

Mr. LUTON. Our total employment this year—average employment for 1960—was 490.

Mr. THOMAS. It goes up to 526 as against 367 for 1959.

Are these man-years?

Mr. LUTON. The 490 and 526 are man-years.

Mr. THOMAS. How many bodies does that mean? It is almost 600; is it not?

Mr. LUTON. In terms of positions, we had 526 positions in 1960 and we will have 564 in 1961.

Mr. THOMAS. It is more than that; is it not?

Mr. LUTON. It represents an increase of 38.

Mr. THOMAS. It is more than that if it is on a man-year basis. You will have 585.

Mr. LUTON. This does not include consultants. This is full time staff.

EMPLOYMENT STRUCTURE

Mr. THOMAS. I was looking over the green sheets, and wondered how many supergrades you have.

Mr. LUTON. We have 55 in our excepted position pay plan.

Mr. THOMAS. You have 55 excepted positions?

Mr. LUTON. Yes, sir.

Mr. THOMAS. How many GS–18's, GS–17's, and GS–16's do you have?

Dr. WATERMAN. We do not have those really.

Mr. THOMAS. Oh, yes; you do.

Dr. WATERMAN. We do not come under the supergrade plan. Ours are excepted positions, approved by the Board.

Mr. THOMAS. How was your personnel structure set up? It was set up by act; was it?

Dr. WATERMAN. It was set up in the National Science Foundation Act.

Mr. THOMAS. That was passed only last year or the year before. How was it originally set up?

Mr. LUTON. We had the excepted position authority in the initial act.

Mr. THOMAS. How does that section read? Do you recall?

Mr. LUTON. Yes, sir. It says that the Director may employ technical and professional people and fix their compensation on the basis of such policies as may be established by the National Science Board.

Mr. THOMAS. And, that was in your original basic act?

Mr. LUTON. Yes, sir.

Mr. THOMAS. Was there any limitation put on it?

Mr. LUTON. No, sir.

Mr. THOMAS. None whatsoever?

Mr. LUTON. No, sir.

Dr. WATERMAN. Would you like the exact statement contained in the act, Mr. Chairman?

Mr. THOMAS. Yes, please.

Dr. WATERMAN. We shall be glad to insert it into the record at this point.

(The matter referred to follows:)

SEC. 15. (a) The Director shall, in accordance with such policies as the Board shall from time to time prescribe, appoint and fix the compensation of such personnel as may be necessary to carry out the provisions of this Act. Such appointments shall be made and such compensation shall be fixed in accordance with the provisions of the civil-service laws and regulations and the Classification Act of 1949: *Provided*, That the Director may, in accordance with such policies as the Board shall from time to time prescribe, employ such technical and professional personnel and fix their compensation, without regard to such laws, as he may deem necessary for the discharge of the responsibilities of the Foundation under this Act. The Deputy Director hereinafter provided for, and the members of the divisional committees and special commissions, shall be appointed without regard to the civil-service laws or regulations. Neither the Director nor the Deputy Director shall engage in any other business, vocation, or employment than that of serving as such Director or Deputy Director, as the case may be; nor shall the Director or Deputy Director, except with the approval of the Board, hold any office in, or act in any capacity for, any organization, agency, or institution with which the Foundation makes any contract or other arrangement under this Act.

Mr. THOMAS. How do you construe "technical and professional personnel"?

Dr. WATERMAN. Those who have either scientific, technical, or administrative professional capabilities at the top positions in the Foundation. These would be positions above the civil service GS–15.

Mr. THOMAS. And how many unclassified positions did you say you had?

Mr. LUTON. We have 55.

Mr. THOMAS. And how many do you have which correspond to a GS–18, and how many correspond to a GS–17?

Mr. LUTON. I can give you a breakdown on that, Mr. Chairman. We have 32 in a salary range from $13,000 to $15,000; we have 11 at salary range of $15,000 to $17,000, and 8 at a salary range of $17,000 to $19,000.

Mr. THOMAS. Those are all what we call excepted positions, are they not?

Mr. LUTON. Yes, sir.

These would be comparable to supergrades under civil service.

Dr. WATERMAN. In our plan which was approved by the board, Mr. Chairman, we have four grades above the GS–15 and call them A, B, C, and D, and these ranges which Mr. Luton identified carry the positions, numbers, and salaries.

Mr. THOMAS. But, they do not correspond with the regular civil service grades of 15, 16, 17, and 18?

Dr. WATERMAN. No, sir; there is only an approximate correlation there.

Mr. THOMAS. Look at it carefully, and do not make too many mistakes now because we have all the agencies looking at you.

The National Aeronautics and Space Administration has some excepted positions, but I do not know of any agency in government which has the latitude that you have. However, in the NASA program there is a limitation put upon the excepted positions, and a

limitation is put upon grades 18, 17, 16, and so forth. So use your authority wisely, and do not bring the roof down on your head.

Gentlemen, this table on page 4 of the justifications tells the tale.

SUPPORT OF SCIENCE

Look at your big subheads here in "Support of science."

You had $67,252,000 in 1959 and $88,025,000 in round numbers, in 1960, and you increased it $30,594,000 for this year, which makes a total of $118,620,000.

It is one thing to grow, but it is something else to take it sort of easy.

You started off here with a little supplemental of about $225,000. Then it went to $3,500,000. In 1953 you had $4,750,000; in 1954, $8 million; in 1955, $12,250,000; in 1956, $16 million; in 1957, $40 million.

Off the record.

(Discussion off the record.)

In 1958 you had $40 million, together with a couple of supplementals to the tune of about $9.75 million.

In 1959 you had $130 million; in 1960, $152,700,000; and now we are up to $190 million. Well, to say the least, we are not timid anyway, are we?

Dr. WATERMAN. In the basic research part of that, Mr. Chairman, we have about the same percentage of estimated requests——

Mr. THOMAS. You take about 60 percent or 65 percent for basic research, do you not?

Dr. WATERMAN. We can only support 37.5 percent of this estimated request for basic research.

Mr. THOMAS. If you are going to put it on that basis, we would have to get some more printing presses and take over all of the universities and high schools and subsidize them.

I notice at several places in the justifications you kept on bemoaning the fact, which was most regrettable, that the universities did not have any money. Where did you get the idea that the Federal Government had more than the universities?

The Federal Governmnt is deeper in debt than the universities. It looks like to me we ought to go to the universities and say, "How about a little help here?"

Dr. WATERMAN. The university heads will be glad to speak to that.

Mr. THOMAS. Dr. Gross, do you agree to that?

Dr. GROSS. No, sir; I think it is the reverse.

Mr. THOMAS. Someone suggested I ask you that question because Duke University had plenty of money and here is the Federal Government only $286 billion in the red.

Dr. GROSS. Yes, sir. Mr. Thomas, anyone who says Duke University or MIT or anyone else has plenty of money, I think Dr. Stratton and I would readily disagree.

Mr. BOLAND. Those were large sums years ago.

Dr. GROSS. This was the point I wanted to emphasize: that this growth pattern of our Science Foundation projects is a modest parallel, I would say, to the growth of costs in education and the expenditures in industrial research and industry and the like. If you are going to take those figures, you will see there is really a very

effective increase in the budget, but it is also to be looked at in the light of total costs and growth of scientific research in industry, and so forth. This is a phenomenal thing.

Mr. THOMAS. I do not suppose we can argue with you too much about that.

BASIC RESEARCH FACILITIES

Under "Basic research facilities," there is really a job. You have the sum of $29,550,000 for 1961.

Dr. WATERMAN. As I say, Mr. Chairman, I want to call your attention to the fact that $15 million of this is in development of graduate research laboratories.

Mr. THOMAS. I read that last night. In the second year of your program you go from $2 million to $15 million in 1 year.

Dr. WATERMAN. The need is, of course, very much greater than that, but we feel we ought to tackle it in an orderly fashion and do this by degrees and, therefore, we feel $15 million one year, followed by——

SURVEYS AND REPORTS

Mr. THOMAS. Under "Surveys and reports," you have $370,000. If we know all of that need exists, why spend $370,000?

Dr. WATERMAN. The important thing there to know is what the trends are, and to find out what is done by the Government, what is done by industry and what is done by universities.

Mr. THOMAS. How is that going to help basic research?

Dr. WATERMAN. Oh, very much. If we find that industry is slackening off, for example, in basic research, this can be called to their attention and similarly, with the Government. This is a way one can get the picture as a whole.

Mr. THOMAS. Can you not spend that money in a much more effective way and produce more results than trying to tell industry they are falling down on the job?

When you tell them, they are liable to give you the Indian sign.

Dr. WATERMAN. These are attracting very favorable attention. We find people are depending on them, and are coming to us for information. I am sure that they are using it in their own planning. I do not see how an effort like research and development in a country as big as ours can be dealt with otherwise.

Mr. THOMAS. We had a little item along that line yesterday. There was a little difference of opinion among the people. Some of them thought industry ought to carry its own load and pointed out that industry did not want any part of it, and there was no need for it. With that thought in mind, it was suggested that the Government go to work on it.

Dr. WATERMAN. The interesting point in the history of this, Mr. Chairman, is when we made our first survey of industry, at first there were objections and a number did not want to go to the trouble. They did not have their books arranged so they could account for the research and development money. But when we went to them and spoke to them about it, we ended up by getting about a 98-percent return on our questions, which is quite a remarkable achievement on any survey. Now, generally speaking, the industries are very glad to furnish these figures on a systematic basis. They have seen the

importance to them of getting these facts and having the overall picture.

DISSEMINATION OF SCIENTIFIC INFORMATION

Mr. THOMAS. Are we going overboard now on dissemination? We have gone through this time and time again. So there is nothing new to any of us in here. You increase it almost $2 million over 1960, up to $7.33 million.

Dr. WATERMAN. This is a subject that has come to a head largely because, as contrasted before the war, there is so much research information which does not get into the regular channels and we cannot expect our scientists and engineers to do their best research unless they know what is going on.

Mr. THOMAS. If you have a scientist, and he is hot on something, I imagine if there is any information available, he is going to find it out.

Dr. WATERMAN. Not if it is not published, and not if it is published in Russian, and things like that. These are things we must now learn to handle.

Also, in the way a scientist views a research job, he looks at periodicals and then he looks at abstracts and summaries of information. These latter have often been rather weak except in fields like chemistry. So this needs bolstering up. The scientist cannot do original work well unless he knows what is going on. Dr. Adkinson can give you in more detail the situation with regard to this if you care to have it. He is head of this office.

Dr. SEARS. One item there I would like to comment on is $2,280,000 for scientific publications. A great majority of those journals so far as I know are supported by private subscription by working scientists and they operate on a shoestring. So I would regard this item as particularly important.

Mr. THOMAS. We will take it out of here if it is supported by the individual scientists. Dr. Waterman does not need it.

Mr. YATES. Which one is that?

Dr. WATERMAN. It is on page 139. The total for dissemination of scientific information is $7,335,000.

SUPPORT OF SCIENCE

Mr. THOMAS. Let us go into details in a minute.

We shall insert at this point in the record page 13 of the justifications.

(The page referred to follows:)

SUPPORT OF SCIENCE, $118,620,000

SUMMARY

The comparative budget estimates by fiscal years for major activities and object of expense in the support of science activity are shown on the following tables:

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
Basic research grants and contracts	$45,950,159	$67,067,116	$78,800,000	+$11,732,884
Basic research facilities grants and contracts	15,524,725	12,800,000	29,550,000	+16,750,000
Surveys and reports	230,254	367,235	370,000	+2,765
Dissemination of scientific information	3,847,527	5,391,531	7,335,000	+1,943,469
Program development, operation and evaluation	1,700,120	2,400,000	2,565,000	+165,000
Subtotal, support of science	67,252,785	88,025,882	118,620,000	+30,594,118
Allocations:				
Department of the Army	14,313	22,099	0	−22,099
Department of Commerce	41,412	2,848,588	0	−2,848,588
Subtotal, allocations	55,725	2,870,687	0	−2,870,687
Total	67,308,510	90,896,569	118,620,000	+27,723,431

Mr. THOMAS. This table here is an awfully good breakdown. You are not spending any money with the Army or the Department of Commerce any more.

What about the National Academy of Sciences? By the way, we sent them a customer yesterday.

Dr. WATERMAN. We provide funds to them for various committees of theirs.

Mr. THOMAS. How much will you give them this year all told?

Mr. LUTON. We do not have that available at the moment. We can furnish it for the record.

Mr. THOMAS. What is it, approximately?

Dr. WATERMAN. We share with NASA the support of the Space Science Board. We supported the Committee on Atmospheric Science and Oceanography; the committee having to do with the IGY, and the following committee that deals with the aftermath of the IGY. We also call on the Academy for rating our applications for graduate fellowships, and so forth. There are a variety of different kinds of items.

Mr. THOMAS. I am aware of that, but I am asking you for an approximate figure as to the total.

Dr. WATERMAN. I would not guess offhand.

Mr. THOMAS. Does anyone have an idea or a good horseback opinion?

Mr. SCHOEN. For the National Academy of Sciences' National Research Council, we have under the support of science three grants last year of $55,840 total and under the support of scientific manpower-type activity we had 11 grants for $159,425. The total is 14 grants for $215,265.

Mr. THOMAS. How much is there for this year?

Mr. SCHOEN. Well, these would be in accordance with developments, sir.

Dr. WATERMAN. We can only estimate that.

Mr. THOMAS. You mean your contribution goes up with the size of the budget? Is that right? So, it would be at least $250,000 this year.

Dr. WATERMAN. In some of these we do not invariably call on the Academy Council unless they have particular competence in the area. We sometimes go outside.

SUMMARY OF EXPENSES

Mr. THOMAS. At this point in the record we shall insert pages 14 and 15 of the justifications.

(The pages referred to follow:)

SUPPORT OF SCIENCE

Summary of obligations by object

		Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
01	Personal services:				
	Staff	$1,258,336	$1,808,000	$1,909,000	+$101,000
	Consultants and committees	90,322	116,000	152,000	+36,000
	Subtotal	1,348,658	1,924,000	2,061,000	+137,000
02	Travel:				
	Staff	80,172	134,000	146,000	+12,000
	Consultants and committees	81,265	120,000	128,000	+8,000
	Subtotal	161,437	254,000	274,000	+20,000
03	Transportation of things	11,828	16,200	12,000	−4,200
05	Rents and utilities	2,271	2,300	3,000	+700
06	Printing	41,316	41,800	43,000	+1,200
07	Contractual services:				
	Administrative contracts	23,132	34,700	35,000	+300
	Security investments	35,774	18,600	13,000	−5,600
	Employee life insurance	3,437	4,800	5,000	+200
	Employee health benefits	0	0	13,000	+13,000
	Basic research, mathematics, physics, and engineering	165,000	200,000	250,000	+50,000
	Facilities, mathematics, physics, and engineering: National Radio Astronomy Observatory	4,405,000	900,000	3,000,000	+2,100,000
	Kitt Peak National Observatory	4,349,925	900,000	2,000,000	+1,100,000
	Atmospheric science facilities	0	500,000	700,000	+200,000
	Surveys and reports	230,254	367,235	370,000	+2,765
	Dissemination of scientific information	294,000	550,000	800,000	+250,000
	Subtotal	9,506,522	3,475,335	7,186,000	+3,710,665
08	Supplies and materials	364	0	0	0
11	Grants and subsidies:				
	Retirement fund	66,361	97,900	100,000	+2,100
	Basic research: Biology and Medical	19,805,483	24,405,177	28,150,000	+3,744,823
	Mathematics, physics, and engineering	22,820,407	33,288,842	41,150,000	+7,861,158
	Antarctic	2,305,903	7,248,097	5,500,000	−1,748,097
	Social sciences	853,366	1,925,000	3,750,000	+1,825,000
	Facilities:				
	Development of graduate laboratories	0	2,000,000	15,000,000	+13,000,000
	Biology and medical	3,269,800	2,000,000	3,000,000	+1,000,000
	University computing facilities	1,500,000	1,500,000	2,000,000	+500,000
	Major engineering-physics research facilities	2,000,000	2,000,000	0	−2,000,000
	Oceanographic research vessel	0	3,000,000	2,750,000	−250,000
	Atmospheric sciences facilities	0	0	800,000	+800,000
	Hawaiian Geophysical Institute	0	0	300,000	+300,000
	Dissemination of scientific information	3,553,527	4,841,531	6,535,000	+1,693,469
	Subtotal	56,174,847	82,306,547	109,035,000	+26,728,453
15	Taxes and assessments	5,542	5,700	6,000	+300
	Subtotal, support of science	67,252,785	88,025,882	118,620,000	+30,594,118
	Allocations:				
	Department of the Army	14,313	22,099	0	−22,099
	Department of Commerce	41,412	2,848,588	0	−2,848,588
	Subtotal	55,725	2,870,687	0	−2,870,687
	Total	67,308,510	90,896,569	118,620,000	+27,723,431

Mr. THOMAS. This breaks it down very well.

Your other objects appear on page 14, and your grants are listed for biology and medical mathematics, physics, and engineering.

What about the Antarctic? I thought we had just about wrapped that up last year.

ANTARCTIC RESEARCH PROGRAM

Dr. WATERMAN. We have an item of $4 million for the Antarctic program; $1.5 million is for the outfitting of a research vessel for oceanographic studies.

Mr. THOMAS. That makes $5.5 million in all?

Dr. WATERMAN. Yes, sir.

Mr. THOMAS. How long are you going to stay there? What is the program?

Dr. WATERMAN. The level is the same this year as last.

Mr. THOMAS. This is not a long-range program; is it?

Dr. WATERMAN. It is an established U.S. program. Its budget will depend really on the need, if it occurs, for making special expeditions to special parts of the Antarctic, or to establish special stations if the scientific need exists.

Mr. THOMAS. How is my friend, Dr. Gould? How is his health?

Dr. WATERMAN. It is fairly good. He is a very busy man these days.

Mr. THOMAS. Tell him we do not like to be neglected like this. We like him.

Dr. WATERMAN. He is chairman of the committee on polar research that advises us on the scientific program.

Mr. THOMAS. Anyway, his health is all right. He was a little bit under the weather a year ago.

Dr. WATERMAN. He is back on his feet; yes.

Mr. THOMAS. He is doing a grand job, of course.

Dr. WATERMAN. Oh, yes; there is no question about it.

UNIVERSITY RESEARCH COMPUTERS

Mr. THOMAS. How long is the program for university computers going to last?

Dr. WATERMAN. I believe Dr. Bolt can answer that better than I.

Dr. BOLT. We think this is with us for a long time.

Mr. THOMAS. Oh, Doctor. You give us such unexpected answers.

Dr. BOLT. We have recent evidence that supports this view. We recently had a meeting on computers with representatives of the NIH; both they and we have been receiving a very rapidly increasing number of requests. We had some leading computer specialists from around the country meet with us to look this problem over and see where it is headed in the future.

There are two ways in which computers are coming in: First, they are greatly increasing the speed at which we can calculate, and, second, computers are becoming part of research as such. You can hook a computer in with the brain of a cat.

Mr. YATES. Why would you want to do that?

Dr. BOLT. There are many different processes taking place along the path from, let us say, the ear of the cat to his cortex. If we can tap-in a computer and "adjust" it to do the same job as the replaced

part of the path, we have learned something about the process at that place on the path. We think that the computer is going to find, and is now finding, its way into research in all fields, in the physical sciences and biological sciences, and in social and psychological sciences.

Dr. WATERMAN. I believe you understand, Mr. Chairman, this item under the heading of "Facilities"—the computing item—is for provision to universities for centers for computing purposes which can be used by most of the departments of the universities.

Mr. THOMAS. How many do we have set up now? I know you had one at Duke University.

Dr. BOLT. There are less than 10 major centers.

Mr. THOMAS. Where are those which we have set up? I know North Carolina has one. Does MIT have one?

Dr. BOLT. Yes, sir.

Mr. THOMAS. How about the University of Southern California? Read into the record where they are located at this time.

Dr. BOLT. In this discussion by the specialists, they defined several types of computers and computer centers, and the most important type they visualize is a very major facility, costing a few millions of dollars, which cuts across the entire institution and university, and is available for new ideas in basic research in all of the departments. According to this definition, there are practically none today, or you might say a couple.

Mr. THOMAS. Off the record.

(Discussion off the record.)

Mr. THOMAS. Tell us where these 10 are located, Doctor.

Dr. BOLT. The ones we have supported are at Cornell, Iowa State, University of Oklahoma, Yale, NCU, Brown, California Tech, Carnegie Tech, Stanford, University of Washington.

Mr. THOMAS. I see Dr. Revelle is practicing a little economy here this year.

Dr. BOLT. If I could comment further, Mr. Chairman, on these that I named; we supplied less than half of the funds that went into these centers.

Mr. THOMAS. Not much less than half. It was a sliding scale and in some instances it was almost 80 percent, was it not?

Dr. BOLT. That is right.

Mr. WATERMAN. In some it was only about 10 or 15 percent. You understand, of course, in connection with our regular research grants occasionally we make a grant for the use of a computer for that particular project. These are for special uses of computers.

OCEANOGRAPHIC RESEARCH VESSEL

Mr. THOMAS. Here is a nice item. Dr. Revelle, I see you are practicing economy. You spent $250,000 on one of your ships. We thought since you got the designs this ought to be about $2,500,000. Aren't you a good contractor? Can't you shave this price a little bit?

Dr. REVELLE. The difference in cost, Mr. Thomas, is just the difference in working drawings for the ships.

Mr. THOMAS. You have already built the prototype. We learned a long time ago when you get that prototype built the cost goes down. You have two already in the water, have you not?

Dr. REVELLE. No, sir.

Mr. THOMAS. When will they be in the water; in about 6 more months?

Dr. REVELLE. The designs for the first one are not yet completed.

Mr. THOMAS. I thought they would be ready in about 6 months. You had the designs completed.

Dr. REVELLE. The designs are being completed by the Institute.

Mr. THOMAS. I thought they were under construction.

Dr. REVELLE. I don't think so.

Mr. THOMAS. We had better defer this and see how the boats go.

Dr. REVELLE. There is just one. So far there is only one vessel being constructed by the National Science Foundation.

Mr. THOMAS. I thought you had two.

Dr. REVELLE. No, sir. One is being constructed by the Navy for the Lamont Geological Observatory. It is a different type, a design developed by the Bureau of Ships called AGOR. This is a different design.

HAWAIIAN INSTITUTE OF GEOPHYSICS

Mr. THOMAS. What about this new item in Hawaii of $300,000. What will be the maintenance and operation cost per year?

Dr. ROBERTSON. The Hawaii Institute of Geophysics will be operated by the University of Hawaii. We are hoping to provide the funds in a 2-year cycle, $300,000 the first year and the remaining amount the following year, which will enable them to put up buildings. They have indicated that they will provide the operating costs thereafter, although we may, and other agencies may, support individual research projects in the institute.

Mr. THOMAS. Do you have any firm understanding about the allocation of the cost for your construction, maintenance and operation?

Dr. ROBERTSON. We have a rather detailed estimate of the total cost. We are planning to give them only $300,000 this year, which will enable them to firm up their estimate.

Mr. THOMAS. Tell us what your construction cost is going to be; then your equipment cost, and then what your maintenance and operation cost will be on an annual basis thereafter.

Dr. ROBERTSON. I do not have the figures right here, but I think we can correct these in the record.

Mr. THOMAS. Give us your horseback opinion. Then straighten it out.

Dr. ROBERTSON. The building costs will be around $2.1 million.

Mr. THOMAS. Will that be a Federal cost, 100 percent?

Dr. ROBERTSON. We are talking to them about the possibility of matching funds for the building itself. This is still in the discussion stage.

Mr. THOMAS. What about equipment? What will that be?

Dr. ROBERTSON. I think we would try to come to some agreement on both the building and equipment. The equipment would be——

Mr. THOMAS. In excess of the $2.1 million?

Dr. ROBERTSON. In addition to the $2.1 million.

Mr. THOMAS. About how much?

Dr. WATERMAN. At least half a million.

Mr. THOMAS. Is that going to be on a 50-50 or 100 percent Government contribution?

Dr. ROBERTSON. This again is the subject we are discussing with them.

Mr. THOMAS. I imagine we can answer that question for you, though.

Dr. ROBERTSON. It will cost $3 million, approximately to build and equip the Institute.

Mr. THOMAS. You are asking for a small downpayment then?

Dr. ROBERTSON. Right.

Mr. THOMAS. What will it cost you to maintain and operate it each year after you get it constructed?

Dr. ROBERTSON. We are not undertaking any commitment to operate this.

Mr. THOMAS. You do not want to build a building and equip it and let it lay idle, do you?

Dr. ROBERTSON. No. The University of Hawaii has stated they will find the general operating funds as part of their regular budget from the State.

Mr. THOMAS. Do you have any written instruments where each party understands what he is supposed to do, his duties and obligations?

Dr. ROBERTSON. They have stated this in writing. This does not mean we might not support individual research projects at the Institute, which would in a sense pay for part of the costs. This would depend on our judgment of the particular research project presented.

Dr. REVELLE. I can give you approximately the cost of the building; $3 million would build and equip about 60,000 net square feet of floor space. This would accommodate something in the order of a hundred scientific staff.

Mr. THOMAS. Dr. Revelle, what particular characteristics led the Board to pick out this particular location? What are you looking for when you go there? What does it have to offer that makes it unique?

Dr. REVELLE. Hawaii offers half a dozen things, actually. The first and most important is that it is in the center of the world's largest ocean and in the center from the point of view of water as well as the point of view of the geometry. You have a very clear, blue, midocean type of environment with special fish, special kinds of organisms of all sorts, and a special atmospheric situation because of its remoteness from land. For example, the whole problem of how rain is formed and how rain falls in a subtropical area like this, is quite different from what it is in much of the United States. Finally, you have an unparalleled opportunity to study the interior of the earth because here you have really the biggest mountain on earth, when you think of it as rising from the bottom of the sea; further, on the island of Hawaii there are several active volcanoes. This is a place where the earth reveals herself through her activities.

Mr. THOMAS. It is quite unique, then?

Dr. REVELLE. In many ways, yes.

DEVELOPMENT OF GRADUATE RESEARCH LABORATORIES

Mr. THOMAS. Let us take a look at your laboratories where you increase $13 million over last year. This is a graduate laboratory. Is

there any limitation on the use of the funds here? Where will you spend this money and in what quantities?

Dr. WATERMAN. This is to be used for nonspecialized research equipment. Specialized research equipment is covered under our normal grants.

Mr. THOMAS. This is for general facilities to take up the slack, so to speak, and what you have not already used in the universities, this is the old mudsill.

Dr. WATERMAN. The point is, our university laboratories are now getting obsolete very rapidly. They do not compare at all with industrial and Government laboratories.

Mr. THOMAS. What is the extent of your program? You are requesting $15 million. What is the extent of your program over the next 10 years?

Dr. WATERMAN. We have thought in terms of an item of this magnitude, or perhaps a little more, for a term of years, possibly something in the order of three or four.

Doing it this way we can do it systematically and thoroughly. We hoped that would cover it. Of course, the needs are really quite great. Dr. Wilson, would you speak about your study of this subject?

Dr. WILSON. From the biological science point of view specifically, this year we are working with $1 million, which is half of the $2 million appropriated last year. In terms of visits, we have visited, I suppose, 65 or 70 universities throughout the country by now.

We have proposals for the million dollars amounting to something between $5 and $6 million, but this figure isn't a true account of what the needs are because in inviting proposals we told them we had only a million dollars.

Mr. THOMAS. You have not allocated your $2 million yet?

Dr. WILSON. We haven't allocated the million. We are having a panel meeting this month. You mean allocated or obligated with reference to the grants?

Mr. THOMAS. I used it as an interchangeable term.

Dr. WILSON. We have the funds allocated. We are working with one-half in the Biological Sciences Division.

Mr. THOMAS. You haven't obligated them?

Dr. WILSON. No.

Mr. THOMAS. Have you obligated any part of your $2 million?

Dr. WILSON. We haven't obligated any but we have, as I say, 84 proposals totaling between $5 and $6 million.

Mr. THOMAS. You will divide it between math, biology, and engineering?

Dr. WILSON. That is right.

Mr. THOMAS. Have you obligated any part of your $2 million?

Dr. WILSON. No, sir. We have between $5 and $6 million worth of proposals which we are evaluating this month in order to obligate the million dollars.

MATCHING FUNDS

Mr. THOMAS. What is your thinking? Under what terms and conditions will you obligate them?

Dr. WILSON. The obligation will be in terms of competition between the proposals as submitted and they will be on a 50–50 matching basis.

Mr. THOMAS. What are you striving for, 50–50, 25–75, 60–40? What are you shooting at?

Dr. WILSON. We are working on a 50–50 matching basis between the universities and the program.

Mr. THOMAS. Are you going to have takers at 50–50?

Dr. WILSON. We have already received about $6 million worth of proposals.

Mr. THOMAS. On the 50–50 basis?

Dr. WILSON. On a 50–50 basis.

Mr. THOMAS. How far are you looking into the future? When you once start it, just read your own figures. This was $2 million last year and it is $15 million this year. Next year it will be 50 or 40. What will it be over a 10-year period?

Dr. WILSON. I think Dr. Waterman can speak to that figure but from the point of view of experience with the program to date, I would say that the $15 million figure is in no sense reaching the amount of need. I think it is a figure which we can use reasonably.

Mr. THOMAS. You cannot be the exclusive judge of need if you are asking the university to put up a little of the funds.

They are going to have to be the judge of needs.

Dr. WILSON. It has been expressed to us on site visits. In these cases we have sent out people to visit the universities and talk about need and proposals as they are submitted.

Mr. LUTON. Could I make one thing clear? Dr. Wilson is just talking about half the program when he mentions these figures. Through December of last year the Foundation has received a total of 216 proposals for about $12,700,000 from the universities.

Mr. JONAS. Will you yield, Mr. Chairman?

Mr. THOMAS. Mr. Jonas.

Mr. JONAS. You said you were considering $6 million in proposals to put up matching funds by universities?

Dr. WILSON. Yes.

Mr. JONAS. Those apply only to the universities and colleges that are able to supply half of the money?

Dr. WILSON. These funds will go only to universities where there is a doctoral program in force and where matching funds are available.

Mr. JONAS. That means that the program will be effective only in the so-called rich or well to do or financially able, financially sound institutions, or is it scattered across the board?

Dr. WILSON. It is scattered across a cross section of universities throughout the whole country.

Mr. JONAS. State universities?

Dr. WILSON. State, private, large, small, so long as the program is at the doctoral level.

Mr. JONAS. Not restricted to the great universities that usually are considered to be out in front.

Dr. WILSON. No.

Mr. THOMAS. You might make the record and put the names of the institutions in.

Dr. WILSON. Forty-three institutions have submitted proposals from the total population.

Mr. JONAS. Do you have a list with you?

Dr. WILSON. Yes.

Mr. JONAS. Can you supply it for the record?

Dr. WILSON. Yes.

Mr. JONAS. Let him put it in the record right here.

Dr. WILSON. We have places like Emory.

Mr. JONAS. You would not call Emory a poor institution.

Dr. WILSON. A small one, not a poor one.

Mr. THOMAS. Read into the record the institutions that you are negotiating with.

Dr. WATERMAN. So far you have only heard about biological and medical science laboratories. Dr. Robertson has a story on the physical and engineering sciences.

Dr. ROBERTSON. We have very much the same experience. We have 132 proposals for $7.4 million, even though people knew our resources this year were very limited.

Mr. THOMAS. Name the institutions that you are in correspondence with or in the process of negotiating with, Dr. Robertson?

Dr. ROBERTSON. We can put that in the record.

I have a list here. There are about 67 different institutions.

Mr. JONAS. Pass it over. We can put it in the record.

(The information requested follows:)

NATIONAL SCIENCE FOUNDATION

Proposals Received Under the Development of Graduate Research Laboratories Program to December 1959

MATHEMATICAL, PHYSICAL AND ENGINEERING SCIENCES

Name of institution and title of proposal	*Amount of proposal*
Carnegie Institute of Technology: Renovation of the Electrical Distribution System for Research Laboratories of the Department of Electrical Engineering	$10,000
Catholic University of America: Renovation and Construction of Graduate Level Research Laboratories in Chemistry	93,189
Columbia University: Renovation and Modernization of the Chemical Research Laboratories—Phase I	153,500
Cornell University: Renovation of Graduate Research Laboratories in Rockefeller Hall, Cornell University	7,785
Harvard University: Improvements in the Lyman Laboratory of Physics	18,725
Indiana University: Renovation of Certain Graduate Research Laboratories in the Chemistry Building	21,250
Kansas State University: Support for Construction of a Graduate Research Laboratory	4,750
University of Kentucky:	
Modernization of Graduate Research Laboratories	4,592
Renovation of Physics Research Laboratories	3,192
Louisiana State University: Renovation of Graduate Level Chemistry Research Laboratory	51,486
University of Michigan:	
Renovation and Construction of Graduate Research Laboratories in the Department of Chemistry	26,000
Renovation of Graduate Research Laboratories	16,425
Modernization of a Graduate Research Laboratory in the Department of Electrical Engineering	14,362
University of Minnesota:	
Modernization of the Physical Chemical Instrumental Research Laboratories	50,000
Modernization of the X-Ray Laboratory in the Department of Geology and Mineralogy	6,050
University of Notre Dame: Modernization of graduate research laboratories	15,400

Name of institution and title of proposal	*Amount of proposal*
University of Pittsburgh:	
Renovation of the Crystallography Laboratory	$11,000
Renovation of the Low-Energy Nuclear and Electron Physics Laboratory	14,357
Rensselaer Polytechnic Institute: Renovation and construction of the Samptson Station of the Observatory of Rensselaer Polytechnic Institute	13,500
The Rice Institute:	
Improvement of graduate research laboratories of organic chemistry	28,200
Renovation and construction of graduate level research laboratory in engineering	17,200
Stanford University:	
Aid to construct a laboratory for a radioactive tracer facility	3,312
Modernization of Graduate Research Laboratory in Structural Engineering	10,000
Stevens Institute of Technology: Modernization of graduate research laboratories	5,000
Syracuse University: Renovation of graduate research laboratories in Bowne Hall (Department of Chemistry)	11,940
Tulane University: Rehabilitation of research laboratory space in the Chemistry Departments of Tulane University	32,995
University of Wisconsin: Modernization of graduate research laboratories	13,332
Adelphia College: Modernization of graduate research laboratories	15,325
University of Akron: Expansion of Graduate Research Facilities in Polymer Chemistry	16,575
California Institute of Technology: Construction of Facilities for Conducting Hazardous Research Experiments	35,312
University of California: Creation of New Research Space, Department of Chemistry	34,850
California Institute of Technology: Construction of a Wet Chemical Analytical Laboratory	11,000
Carnegie Institute of Technology: Extension of the Cyclotron Room, Nuclear Research Center	20,000
University of Cincinnati: Modernization of Laboratories for Research in Physical and Chemical Geology	44,513
Clemson College: Installation of Laboratory Furnishings in Brackett Hall, Clemson College	1,897
Cornell University: Modification of Two Research Rooms in Baker Laboratory	5,549
Georgia Institute of Technology:	
Basic Research Fatigue Laboratory in the School of Industrial Engineering	15,000
Additional Sanitary Engineering Research Facilities for Basic Research	15,500
Harvard University: Renovation and Construction of Facilities for Geochemical Research	164,000
University of Houston: Rehabilitation of Space for Graduate Research Laboratories	2,789
Howard University: Installation of Graduate Level Research Laboratories in the Attic of the Chemistry Building	28,250
University of Illinois:	
Remodeling Program for Physical Chemistry	105,000
Expansion of Research Facilities of the Digital Computer Laboratory	190,000
Indiana University: Modernization of Graduate Research Laboratories	17,500
Louisiana State University: Request for Radioisotope and Radiation Laboratory	132,637
University of Maryland: Improvement of Facilities of the Graduate Research Laboratory Used for the Investigation of Elementary Particle Interactions	10,450

Name of institution and title of proposal	*Amount of proposal*
Massachusetts Institute of Technology: Modernization of two Laboratories in the Metallurgy Department	$1,415
University of Michigan:	
Renovation of Graduate Research Laboratories	12,907
Renovation and Construction of Graduate Research Laboratories in the Department of Geology	7,236
University of Minnesota:	
Additional to the Graduate Research Laboratories	21,825
Construction of Research Rooms for Mathematics	4,225
Mississippi State University: Modernization of Graduate Research Laboratories	69,765
University of New Mexico: Modernization of Graduate Research Laboratories	7,475
University of Notre Dame—Modernization of Graduate Research Laboratories	12,093
Ohio State University: Remodeling a Portion of the Space in the McPherson Chemical Laboratory and to make a Laboratory for Graduate Research in Radiochemistry	55,000
University of Oklahoma: Modernization of Graduate Research Facilities	8,628
University of Pennsylvania:	
Renovation and Construction of a Graduate Research Laboratory in the Moore School of Electrical Engineering	10,571
Construction of a Laboratory for Electron Microscopy	10,237
Increasing Research Laboratory Space in the Physics Department	15,000
Purdue University: Modernization of Graduate Research Laboratory	24,850
Rensselaer Polytechnic Institute: Construction of Concrete Laboratories	56,000
Stanford University:	
Transport Processes Research Laboratory	8,782
A Small-Scale Fluid Mechanics Laboratory for Doctoral Research	5,000
Stevens Institute of Technology: Modernization of Graduate Chemical Engineering Research Laboratory	3,000
State University College of (Syracuse University) Forestry: Renovation of Laboratories for Research in Pulp and Paper Technology	4,350
Syracuse University: Modernization of Graduate Research Laboratories	32,934
A. & M. College of Texas: Development of a Graduate Level Research Laboratory in the Soil Mechanics Division of the Civil Engineering Department	17,022
Tufts University:	
Construction of Machine Shop and Laboratory Space for Graduate Research in Inorganic and Physical Chemistry	15,150
Renovation of the Graduate Research Laboratories	40,000
Tulane University: Research Laboratory Construction, Department of Geology	7,137
University of Wisconsin:	
Reconstruction of Two Rooms as Laboratories and Renovation of One Laboratory Room	7,455
Modernization and Rehabilitation of a Graduate Research Laboratory for Research in Semiconductor Electronics	7,410
Indiana University: Modernization of Graduate Research Laboratories	21,768
Kansas State University: Renovation of Graduate Level Research Laboratories in Chemistry	12,992
University of Louisville: Fixed Equipment for Graduate Research Laboratories	5,000
University of Maryland: Experimental Facility Improvement of the Graduate Research Laboratory	15,725

Name of institution and title of proposal	*Amount of proposal*
University of Michigan:	
Equipping the Fluids Science Laboratory	$3,459
Development of a graduate research laboratory in the Department of Electrical Engineering (Solid State Laboratory)	12,450
Modernization of Graduate Research Facilities for the Department of Nuclear Engineering	17,000
University of Minnesota:	
Expansion of Research Laboratory Facilities in Geochemistry	3,150
Plasma Jet Facility Support	8,322
Remodeling Organic Geochemistry Laboratory	9,350
New Mexico Institute of Mining & Technology:	
Modernization of Graduate Research Laboratories used in Ice and Tritium Studies	4,185
Installation of an Elevator Facility in the Research Building of the Institute	8,750
University of New Mexico: Complete Furnishing of Laboratory Space for the Department of Chemistry	11,116
Ohio University: Modernization of Graduate Research Laboratories	32,003
Oklahoma State University: The Renovation and Modernization of Two Graduate Research Laboratories	18,388
Pennsylvania State University: Construction of a Graduate Level Research Laboratory Facility (High Stagnation Temperature Wind Tunnel Facility)	12,000
University of Pennsylvania: Modernization of Graduate Research Laboratories in Mechanical Engineering	20,709
Rensselaer Polytechnic Institute:	
Renovation of Research Laboratories	8,950
Supersonic Research Facility	9,050
Modernization of a Laboratory for Graduate Research in Corrosion and Related Phenomena	5,438
Vanderbilt University: Modernization of Graduate Research Laboratories for Physical Sciences in the Andrew B. Learned Hall	45,379
Renovation of Graduate-Level Research Laboratories in the Department of Chemistry	6,817
Washington State University: Modernization of the Research Facilities of the Organic Chemistry Division	10,150
University of Washington: Modernization of the Brittle Coating Research Laboratory	1,822
University of Wyoming: Construction of Hood for Graduate Research Work	350
The Florida State University: Modernization of Graduate Research Laboratories in Meteorology	33,000
University of Georgia: Establishment of Modern Graduate Research Laboratories in the Department of Chemistry	50,994
Iowa State University: Assistance in Enclosing Two Open Courts of the Physics Building	55,000
University of Michigan: Construction of Research Facilities for the Institute for Social Research	110,000
New Mexico College of Agriculture & Mechanic Arts: Construction of Graduate Level Laboratories and Facilities for Basic Research in the Natural and Engineering Sciences	21,904
North Carolina State College: Modernization of Graduate Research Laboratories in the Department of Mechanical Engineering	31,950
University of North Dakota: Construction and Equipping of a Portion of New Graduate-Level Research Laboratories	55,961
The Pennsylvania State University: Modernization of Graduate Research Laboratories	9,500
University of Tennessee: Modernization of Graduate Research Laboratories in Physics	68,250
Virginia Polytechnic Institute: Support of a Multipurpose Chemistry Laboratory for the Physics Department	2,400
Wayne State University: Fixed Equipment in the Life Sciences Research Center	150,000

Name of institution and title of proposal	*Amount of proposal*
West Virginia University: Establishment of a Servomechanism Research	$4,250
Polytechnic Institute of Brooklyn: Construction of Graduate Level Research Laboratories	247,500
Brown University: Construction of a Science Library at Brown University	500,000
University of Illinois:	
Modernization and Expansion of Graduate Research Laboratories in Civil Engineering	18,500
Construction of Research Buildings at the Betatron Laboratory	28,200
Princeton University: Construction and Furnishing of Graduate Research Laboratories in Units B and C of the New Engineering Quadrangle	375,000
Stanford University:	
Renovation to Extend the Capabilities of the Mechanical Engineering Laboratory for Research by Photographic Techniques	2,375
Construction of a New Physics Research Laboratory at Stanford University	700,000
University of Texas: Assistance in the Construction of a Building to House a Major Computer Installation	100,000
University of Wisconsin:	
Modernization of Facilities for Graduate Mathematics Research	110,000
Construction of a Laboratory for High Energy Physics	72,500
University of Arizona: Support of Construction of a Research Laboratory for the Study of Imperfections in Metals	1,856
The Catholic University of America: Support of a Graduate Research Laboratory Facility in the Department of Electrical Engineering	30,000
Georgia Institute of Technology: An addition to the Chemistry Annex	141,150
Indiana University: Fixed Equipment for the planned graduate research wing of the Chemistry Building at Indiana University	145,605
Johns Hopkins University: Enlargement of the Physics Laboratory	1,248,500
Kansas State University: Support for Construction of Graduate Research Laboratories	6,000
Louisiana State University: Renovation and/or Construction of Graduate Level Research Laboratories	110,000
University of Michigan: Construction of an Addition to the Meteorological Laboratories	22,500
Pennsylvania State University:	
Support of Part of Construction Costs of an Addition to the Geochemistry Research Laboratories	90,000
Construction of Graduate Level Laboratories for Basic Research in the Natural and Engineering Sciences at the Nuclear Reactor Facility	13,293
Rensselaer Polytechnic Institute: Construction of Electron Physics Laboratory	12,500
The University of Rochester: Addition of Wing to Bausch and Lomb Building	528,464
University of Wisconsin: Aid in the Construction of a Research Laboratory	7,000
Mathematical, Physical and Engineering Sciences, Subtotal (132 proposals)	7,397,681

BIOLOGICAL AND MEDICAL SCIENCES

Cornell University: Construction of New Plant Physiology Laboratories	145,900
University of Chicago: Renovation and Furnishing of Zoology Research Laboratories (Whitman Lab)	67,450
University of Wisconsin: Construction of New Floor for Protein Biochemistry	97,500
Emory University: Ventilating System for Biochemistry Department	21,000

Name of institution and title of proposal	*Amount of proposal*
University of North Carolina: Construction of an Animal Metabolic Research Facility	$124,450
University of Pennsylvania: Equipment in New Central Microbiological Media Room	25,200
Georgetown University: Renovation of Research Laboratories	33,400
University of Chicago: Modernization and Rehabilitation of Graduate Research Facilities	2,500
Kansas State University: Modernization of Graduate Research Laboratories Program	850
Indiana University: Modernization of Animal Rooms for Physiological Research	23,100
Rockefeller Institute: Furnishing and Equipment for Graduate Research laboratories	41,900
University of Florida: Furnishing and Equipping Bacteriology Laboratory	5,000
Mississippi State University: Modernization of Zoology and Entomology Graduate Research Laboratory	2,500
Duke University: Furnishing Botany and Zoology Research Laboratories	155,500
University of Michigan: Renovation of Fisheries Research Laboratories	34,000
University of Minnesota: Renovation of Laboratory for Photosynthetic Research	1,500
Cornell University: Construction of laboratories for research in plant virology and plant nematology	74,800
University of Minnesota: Modernization of graduate laboratories for zoological research	5,000
University of Michigan: Renovation of zoological research laboratories	38,000
University of Illinois: Remodeling of anatomy research laboratory	5,300
University of Kentucky: Construction of isolation units for equine research	36,900
University of Wisconsin: Renovation of botanical research greenhouses	9,700
University of Illinois: Remodeling biochemistry research laboratory	12,000
Pennsylvania State University: Furnishing a virology and tissue culture laboratory	12,500
University of Pennsylvania: Completion and furnishing of biology animal building	47,500
Tulane University: Expansion of insectary and other facilities for parasitological research	3,350
University of Nebraska: Renovation of entomology laboratories	5,500
Kansas State University: Construction of isolation cages	600
Rutgers University: Completion and furnishings of biological research laboratories	109,400
University of Missouri: Renovation of research facilities in department of zoology	24,500
University of California: Renovation of research laboratories for plant pathology, soils and plant nutrition	150,000
Purdue University: Construction of research greenhouses	82,700
University of Florida: Furnishings of Botany Research Laboratories	4,100
Vanderbilt University:	
Renovation and Furnishing of Research Laboratory in Plant Histology	2,000
Construction of Greenhouse for Research Use	9,600
University of Arizona: Construction of Greenhouse and Headhouse	7,000
Brown University: Construction of Science Library	425,000
Wayne State University: Fixed Equipment for Life Sciences Research Center	150,000
Louisiana State University: Refurbishment of Laboratories for Isotopic Tracer Research	132,600
State University of South Dakota: Furnishing of Physiology, Pharmacology and Biochemistry Research Laboratories	5,000
Tulane University: Furnishing Biology Research Laboratories	9,000

Name of institution and title of proposal	Amount of proposal
Washington State University:	
Renovation and Furnishings for Bacteriology and Public Health Laboratories	$3,500
Renovation and Furnishings for Botany Laboratory	3,700
Indiana University: Furnishings for Bacteriological Research Laboratories	9,400
University of Wisconsin: Renovation of Zoological Research Laboratories	9,800
Tulane University: Furnishing of Tropical Medicine Research Laboratories for Graduate Students	31,600
Vanderbilt University:	
Furnishing of Anatomy Research Laboratories	4,300
Furnishing of Biochemical Research	17,600
Furnishing of Biology Research Laboratory	23,200
Furnishings for Laboratories for Department of Microbiology	48,600
Furnishing of Research Laboratories for Pathology	13,500
Furnishings of Laboratories for the Department of Physiology	23,900
Western Reserve University:	
Construction of Botanical Research Laboratory	10,000
Renovation and Improvement of Primate Behavior Laboratory	1,250
Remodeling of Embryology Laboratories	1,400
University of Michigan:	
Renovation of Plant Physiology Research Laboratories	18,300
Furnishing of Pharmacy Research Laboratories	70,250
State University College, Syracuse University: Renovation of Forest Science Research Laboratories	19,200
University of Minnesota: Construction of a Botany Research Laboratory	2,200
Pennsylvania State University: Renovation and Furnishings for Animal Nutrition Laboratory	5,000
University of Minnesota:	
Furnishings for Plant Science Research Laboratories	54,000
Modernization of Animal Husbandry Research Laboratory	1,900
Pennsylvania State University: Furnishings for Plant Science Research Laboratories	44,400
University of Connecticut: Research Wing for Life Science Building	826,200
University of Pennsylvania: Renovation of the Biological Engineering Research Laboratories	6,200
University of Michigan: Modernization of Graduate Research Facilities for Forest Biology	26,000
Pennsylvania State University: Furnishings for Laboratory for Food and Nutrition Research	2,000
University of Illinois: Construction of Laboratories for Electron Research Laboratories	1,500
University of Illinois: Construction of Laboratories for Election Microscopy	250,000
University of California: Construction of a Laboratory for Photosynthesis and Chemical Biodynamics Research	627,500
University of Michigan: Construction of Laboratories for Botanical Gardens	239,500
Virginia Polytechnic Institute: Research Laboratories for Biochemistry, Microbiology and Nutrition	52,700
Washington University (St. Louis): Renovations and furnishings of a Laboratory for Plant Histology	1,900
Medical College of Virginia: Renovations and Furnishings for Pathology Research Laboratories	13,500
University of Southern California: Modernization of Graduate Life Science Research Laboratories	115,400
University of Wisconsin: Furnishing Laboratory for Physical Anthropology	8,600
University of Oregon: Completion and Furnishing of Biological Science Research	83,700
University of California: Renovation and Furnishing of Laboratories for Pharmaceutical Research	20,000

Name of institution and title of proposal	*Amount of proposal*
University of Nebraska: Construction of Walk-In Cold Room	$1,000
New Mexico Highlands University: Facilities and Laboratories for Continuation of Graduate Research Program	263,000
Kansas State University: Renovation and Furnishing of Attic Space for Bacteriological Research in School of Veterinary Medicine	22,000
University of Wisconsin: Renovation and Furnishing Laboratories for Veterinary Pathology Research	6,000
University of Minnesota: Dairy Husbandry Research Laboratories	36,100
Tulane University:	
Furnishings for Physiology Research Laboratories	18,300
Modernization and Furnishing of Biochemistry Research Laboratories	16,400
University of Georgia: Furnishing and Modernization of Graduate Research Laboratories	22,900
Southern Illinois University: Modifications of animal House and Greenhouse	18,100
University of Kentucky: Primate Behavior Research Laboratory	24,900
Biological and Medical Sciences, Subtotal (88 proposals)	5,264,200
Total (220 proposals)	12,661,881

BASIS OF ESTIMATE

Mr. THOMAS. How do you arrive at this figure of $15 million for this year?

Dr. ROBERTSON. I think this is a very reasonable figure when we look at the need. We made an estimate on the basis of many visits.

Mr. THOMAS. Doctor, do not fall into the error that you will be the exclusive judge of need because these universities will be the final judge of need.

Dr. ROBERTSON. This is based largely on conversations with the universities as to things that they need for which they are able and willing to put up matching funds.

Mr. THOMAS. What do you think your program will cost in mathematical, physical, and engineering sciences over a period of 10 years?

Dr. ROBERTSON. That is a hard estimate to make. I think our immediate needs would come close to $50 million.

How this would extend over a period of 10 years, I do not know, but there is no doubt that all of the institutions, including some of the major ones, have fallen behind in this matter of facilities for research.

Dr. REVELLE. Let me give you some figures on this from the standpoint just of scientific manpower. We are producing annually now something like 4,000 Ph.D.'s in the sciences. In order to be effective, in research each one of these men needs to have about a thousand net square feet of laboratory space for himself and his students, if he is going to be effective in teaching and in research. This means that each year you need to add something like 4 million net square feet of laboratory space to the research facilities of the country. The best estimates that I know of for the cost of laboratory space per net square foot, with some equipment, is about $50 a net square foot. This means that each year you need to build.

Mr. THOMAS. Off the record.

(Discussion off the record.)

Dr. REVELLE. If you take the kind of laboratory space that is suitable, I think $50 a net square foot is not too far off. This means that

you need to build each year about $200 million worth of laboratory buildings.

Mr. THOMAS. If you are talking about square footage, yes. I thought you were talking about equipment with it.

Dr. REVELLE. That is with the basic equipment, so that the needs of the country, if we are really going to do what we were trying to do this morning, namely, to catch up quantitatively and qualitatively with the Russians, really means we have to build $200 million worth of laboratory space each year. This figure that Dr. Robertson is talking about of $40 or $50 million for the Federal Government, for this part, as you can see, comes well within the figures.

Mr. THOMAS. Are we getting into the position of having an agency in Government sitting here in Washington dictating to the universities throughout the country a scientific program? What are your strings attached to this money?

Dr. WATERMAN. Such a position is completely against our philosophy all along, Mr. Chairman. As you know, we try to follow the lead of scientists in what is needed. We have as a check on this the deliberations of our National Science Board so we are very careful not to dictate.

Mr. THOMAS. The Board is made up of good old human beings like every other body.

Dr. REVELLE. Our position is we cannot increase our research a bit without additional research facilities.

Mr. JONAS. That observation interests me. As I sit here and listen to you gentlemen, I begin to suspect that we have the cart before the horse.

I do not see how we can profitably spend $75 or $80 million in basic research when these people that will do the research do not have adequate facilities in which to work. Maybe we ought to take about $50 million out of that and start acquiring the facilities and then begin to put them to use. What about that, Dr. Waterman?

Dr. WATERMAN. The purpose of this item is to enter that picture and try to do right by the other side.

Mr. JONAS. What if we cannot do both? You need the facilities more than you need the other. You need that as a basis or background or beginning point.

Dr. WATERMAN. It is an important basis but in the meantime we have to get on with the most modern up-to-date research. This is taken care of with our regular grants. We do provide the special equipment for this special research. They can do it even when the general environment is not too good. They can get on with it. Now, we are trying to get a broader base, just as you suggest, without interfering with single projects which ought to be done.

Mr. THOMAS. Suppose you spend $100 or $150 million on this in the next 10 years building and equipping laboratories. What is going to be the maintenance and operation cost thereafter?

Dr. REVELLE. The maintenance and operation cost of the scientists that occupy the buildings.

Mr. THOMAS. What will be the cost of this budget?

Dr. WATERMAN. We do not contemplate operating costs in this. This is just an attempt to bring things up to date.

Dr. STRATTON. Mr. Chairman, I would like to comment on that because I feel Mr. Jonas has put his finger on some very important points.

Dr. WATERMAN. Yes, he has.

Dr. STRATTON. We ought to face up whether we like it or not to all the factors involved in this. There is no use trying to provide more and more funds for research when we haven't any place to put it. There is no use giving money for space unless we recognize it will represent additional operating costs.

Whether those ought to be paid by the Government or the State or the private institution, I do not think is just a matter of principle. It is a question of where the funds will come from. Take your matching grant business. I personally think this is an extremely wise and good idea. I am not sure it is feasible. If we take your figure of $200 million, and I think if we are entirely candid you know that is a modest figure, and I know it is very much greater. You cannot define what is need. If need is defined by the willingness of the university to undertake this obligation, then I do not think the universities are going to find it easy to get $200 million. They have not got the resources themselves. If I can take a moment more, Mr. Chairman, to sort of bring out the kind of a juncture at which we are, I would like to preface this by making clear that I speak not of the large, small, nor private, nor public; this is a national problem.

You spoke of the origin 10 years ago of this Foundation starting with a few hundred thousand dollars and now it is $160 million or $190 million, be it as you will. Fifteen years ago and after the war, this work was begun, this increase by the Office of Naval Research, by the various other agencies of the National Defense Department and what we have been doing is putting an increasing amount of money each year into basic science and education for science.

Why do we do it? Because of a conviction here in Government, and I think among the people, that science and research is of overriding importance to the survival of this country both economically and militarily. That is fine. It is a matter of national policy. When the National Science Foundation makes grants or contracts, it does it not as a philanthropic matter. We sit here entirely in a different capacity as trustees of this Board instead of the Rockefeller Foundation because this is national policy and national need. That is good. Then we turn to the universities and ask them to take on this task.

It is only reasonable to ask that they should share in the costs, but the effect has been to lift the level of university operation in science and research and teaching a whole order of magnitude above anything we could do in 1946 or 1950.

The net consequence is that the universities, be they State or private, have lost contact with the roots of their original support, and whether we are talking about indirect costs or the problem of graduate facilities or the support of basic research, it comes to the same thing.

It isn't whether the universities should share the cost. Where are they going to get the additional money to do it?

Now, to some degree the State universities can turn to the State legislatures. Perhaps that is what they should do. Private insti-

tutions try to get more endowment and gifts. All of us are working hard on that problem. I think we must be aware that the effect on the private institutions is not to turn to the student to increase his tuition so we price him out of business. What I am pleading for here is looking at the problem we start with the question: What does the country need, what should be the scale of our total effort, and then how will we distribute, where will we find the funds to accomplish this thing?

It cannot come out of the resources of the universities any more. I know Dr. Gross will say that is true. They frankly have not got those funds. Coming back to this particular point, one of the very grave needs, as I observe it, is for help in capital facilities. We went all out for a while after the war in supporting research. I think that is still important. There is no use going beyond there to where we do not know where to put the people.

Mr. THOMAS. We see lots of this, for your information. We on this side of the committee sit on various committees, from the Armed Services through your agency here and through practically every scientific agency in the Government. We are quite familiar with the problems, et cetera.

Dr. GROSS. Could I comment, Mr. Chairman?

Mr. THOMAS. Yes.

Dr. GROSS. I would want to endorse heartily the point of view expressed by Dr. Stratton. I would like to add perhaps a comment.

Mr. THOMAS. We are spending more for basic research each year than the previous year in all departments of Government. I think the figures are around $4 or $4½ billion this year.

Dr. GROSS. You made another comment. I think this has had a very profound and important effect on industry and industrial research, which is a very large sum, even compared to what we are talking about, in their awareness of their responsibility. Dr. Stratton and I were in a group and I became familiar with some figures which indicated their awareness of the necessity for basic research.

Mr. THOMAS. They spend almost as much as Government.

Dr. GROSS. That is right. The other point is I think the staff, and Dr. Stratton will remember up at Endicott House, where we met, the staff has approached this really more conservatively than the Board would have. You may say we are human beings. I grant that, but I think those of us who are in the universities have felt this tremendous pressure that we have not the space and at the same time the staff—I remember a figure, Allen, if I am right, of $50 million as a very careful estimate by some of our group made 4 years ago, if I remember rightly, for this particular purpose.

Mr. THOMAS. Do you think the Government should share in the maintenance and operation and administrative costs? Dr. Waterman says 25 percent. There is no limitation on these funds. The NIH bill has a 15-percent limitation. There is no limitation in here. What part of these funds should be used for administrative purposes by the institutions? Is it necessary for the Federal Government——

Dr. WATERMAN. None of these. It is under research grants that we are talking about the 20 percent.

Mr. THOMAS. It will be here, too.

Dr. WATERMAN. These are capital costs only.

Mr. THOMAS. Is it necessary for the Federal Government to support administrative expense as well as instruction and all types of capital equipment?

Dr. GROSS. I think it is, Mr. Chairman.

Might I comment on Mr. Jonas' question? I am rather anxious to point out that the feeling of the Board, Mr. Jonas, is that this should be, in every way possible, an across-the-board effort. You brought the point out about the types of institutions. I think I reflect the sentiments of the Board that this is not to be going in one particular type of institution or direction because the need, as I think the people have been aware of out in the field, and the observations of those of us on the Board, clearly indicates this is necessary. It is needed as much in the smaller universities and colleges. The need is tremendous for this.

INSTITUTIONS SUBMITTING PROPOSALS

Mr. THOMAS. Where is the list of people and institutions that are interested in this $15 million for 1961 in the field of biology and in the field of engineering and math? Do you have those two lists there?

Dr. WILSON. I have a list of the 88 proposals from the institutions.

Dr. WATERMAN. We have a list from Dr. Robertson of 132 proposals.

Dr. ROBERTSON. I have the same type of list, proposals received up until December 1. There will be some other institutions which will come in later, I am sure.

Mr. THOMAS. Read off a few of them. How are they distributed geographically?

Dr. ROBERTSON. These are arranged by subject matter, but the first ones I see are Florida State University and the University of Michigan.

Mr. JONAS. Mr. Chairman, would you let him indicate what type of facility?

Mr. THOMAS. Go ahead.

Dr. ROBERTSON. Modernization of graduate research laboratories in meteorology at Florida State University; construction of an addition to the meterological laboratory at the University of Michigan; then here are a couple in chemistry: modernization of research laboratories at Adelphia College, on Long Island; and expansion of graduate research facilities in polymer chemistry at the University of Akron, Ohio.

Mr. THOMAS. I wonder if you would be good enough to submit a copy of that for the committee and give us the opportunity of looking it over? We may need it for the record.

Dr. WATERMAN. Surely. To add one point to what Dr. Stratton and Dr. Gross have said, with the tremendous increase of undergraduate population facing the universities one of their greatest problems is to accommodate the increase in the undergraduate body, for classrooms, laboratories, dormitories, et cetera. This is their huge problem. It is all they can do to meet that. Graduate research suffers by comparison. It is here we feel the Foundation can make a real contribution. Research is getting lost in the shuffle. It is a minor part of their problem but a most important one.

Mr. THOMAS. What about some of these institutions that are all severely overcrowded and very few students can get into them, par-

ticularly only those with an A plus record. If you put in Federal money, here comes the B and C student, who wants to get into them. He can't do it.

Dr. WATERMAN. That is a real problem.

Mr. THOMAS. His papa's money is helping to finance them.

Mr. YATES. Maybe Dr. Stratton would want to speak to that.

Mr. THOMAS. Well, Doctor—this is the first time he has been here. Let's not put him on the spot.

Dr. STRATTON. Off the record.

(Discussion off the record.)

Mr. THOMAS. How are we going to explain this to the people?

You call some of these institutions and the first thing they ask you is, "Do you have an AA record?" If you do not have, they hang up the telephone and almost insult you for calling.

Dr. WATERMAN. We do not propose here to deal at all with the undergraduate body. This is entirely for graduate research. The other is an enormous problem, but not one that we should get into at the present time because it covers all fields of knowledge.

Mr. THOMAS. You are not going to tell institutions how to use this laboratory, are you? I thought you told me you did not have strings on it a while ago.

Dr. WATERMAN. It is for graduate research in science, not undergraduate instruction.

Mr. THOMAS. There is a string already. You are telling them how to use it.

Dr. WATERMAN. That is the only thing we can do. We do not tell them how to use it. We provide the money to assist scientific research purposes in general.

FUNDS FOR UNDERGRADUATE WORK

Mr. YATES. Can any of these funds be used for undergraduate scientific work?

Dr. WATERMAN. No.

Mr. YATES. Do you have other funds for universities that can be used for undergraduate scientific work?

Dr. WATERMAN. We have not entered that problem at all except in special grants in Dr. Kelly's area.

Mr. THOMAS. We give them a postdoctoral staffing and then furnish the laboratory.

Mr. YATES. I wondered whether they were not also going into the field of undergraduate work for the universities. Is that the next step?

Dr. WATERMAN. We already are doing that in a small experimental way.

We call this undergraduate participation in research. We are making selected grants here and watching them carefully.

Mr. YATES. Then you have to answer Mr. Thomas' question, do you not?

Dr. WATERMAN. This has nothing to do with the equipping of undergraduate laboratories or costs of instruction. These are to enable a science teacher in a university to spend more time and have available research equipment for undergraduates to do research of their own kind. It is not as advanced as graduate students, but it puts

them on their mettle. They can take special assigned problems which to them is research. Wherever this has been tried it has been very helpful in getting great enthusiasm and progress on the part of the undergraduates. But this is specifically for special students, you see, not for general laboratory purposes or classrooms.

Basic Research Grants and Contracts

Mr. Thomas. Let us take a look at basic research grants and contracts.

Put pages 17, 18, 19, and 20 in the record.

(The pages referred to are as follows:)

Basic Research Grants and Contracts, $78,800,000

SUMMARY

The comparative budget estimates and the percent of total for each program area under basic research grants and contracts are shown on the following table:

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
Biological and medical sciences	$19,805,483	$24,405,177	$28,150,000	+$3,744,823
Mathematics, physics, and engineering sciences:				
Basic research	22,985,407	31,488,842	39,400,000	+7,911,158
Weather modification	0	2,000,000	2,000,000	0
Subtotal, M. P. & E	22,985,407	33,488,842	41,400,000	+7,911,158
Antarctic research	2,305,903	7,248,097	5,500,000	−1,748,097
Social sciences research program	853,366	1,925,000	3,750,000	+1,825,000
Total	45,950,159	67,067,116	78,800,000	+11,732,884
Percent of total:				
Biological and medical sciences	43.1	36.3	35.7	
Mathematics, physics, and engineering sciences:				
Basic research	50.0	47.0	50.0	
Weather modification	0	3.0	2.5	
Subtotal, M. P. & E	50.0	50.0	52.5	
Arctic research	5.0	10.8	7.0	
Social sciences research program	1.9	2.9	4.8	
Total	100.0	100.0	100.0	

The increase of $11,732,884, or 17.5 percent over the fiscal year 1960 level of $67,067,116 for basic research is predicated on continued increases in the number and dollar value of requests for research support received in the Foundation. Notwithstanding the fact that in no year has the Foundation been able to support more than 37 percent of the total dollar value of research proposals received, the requests for support continue to increase markedly from year to year. The following table shows the annual rate of growth in the dollar volume of proposals received, grants awarded and the percentage of support provided:

Dollar volume of basic research proposals received and grants awarded in the life, physical and social sciences

[In thousands]

Fiscal year	Dollar amount of proposals received	Percent of increase from prior year	Dollar amount of grants awarded	Percent of increase from prior year	Percent of total dollar value of proposals supported
1955	$24,828		$8,009		32.2
1956	36,944	49	9,492	19	25.7
1957	58,209	58	14,979	58	25.7
1958	93,392	60	18,630	24	19.9
1959	123,438	32	43,644	134	35.4
1960	157,000	27	57,819	32	36.8
1961	190,000	21	71,300	23	37.5

NOTE.—This table does not include weather modification program or antarctic research. Fiscal years 1960 and 1961 are estimated.

The basic research supported through the Foundation's research programs covers the total range of the life physical sciences and several of the principal areas of the social sciences. The principal investigators are individuals of recognized professional competency, or young scientists who have ably demonstrated the capacity to conduct research in their chosen field. Applications for support received in the Foundation are reviewed in the program area appropriate to the scientific field involved. Following review and evaluation of proposals by outside qualified scientists, the National Science Foundation awards grants to those investigators whose proposals are considered to have the greatest scientific potential.

The constantly increasing dollar volume of proposal receipts is a strong indication that sufficient support for basic research is not available from non-Government sources. Because recognition must be given to the vital importance of continued increases in the Nation's basic research efforts, the Foundation believes it has a responsibility to request increased appropriations to provide support for the increasing dollar value of research proposals received. It would be the ultimate in inconsistency to promote improved education in the sciences and at the same time fail to provide research funds for trained investigators.

The total amount of $78,800,000 requested is a large and significant sum, yet it is estimated that the amount will provide support for only about one-third of the total dollar value of proposals received. Many competent scientific investigators who are not supported by the Foundation find it necessary to curtail their basic research efforts or possibly to turn to other areas of scientific endeavor. As a consequence, much basic research is delayed or lost. Basic research should not be regarded as a commodity that is subject to the law of diminishing returns. It is a commodity that will be in constantly increasing demand as long as we strive for progress in science.

The cost of conducting basic research is increasing from year to year and is a factor which must be considered in this request for increased funds. Salaries are higher, modern equipment is more expensive and the costs of supplies, travel and other expenses related to research projects continue to increase. The effects of this increase in the cost of doing research are twofold. First, individual requests are larger, which tends to reduce the number of grants the Foundation can award unless there is a corresponding increase in the research funds appropriated. And secondly, the increasing costs of conducting basic research, with its inherent uncertainty of productivity, tend to encourage private fund sources to gravitate toward applied science support where the possibility of a return on investments appears more likely to occur. The end result of this diminishment of private capital is an increase in the demand for Government funds for basic research.

An indication of the rate at which the cost of conducting basic research has increased may be ascertained in a review of the experience of the Foundation since fiscal year 1958. The value of the average research grant in fiscal year 1958 was $17,200 and in fiscal year 1959 it was $25,900. It is estimated, based on actual experience through September 1959, that the average research grant in fiscal year 1960 will be about $30,500. The amount will probably increase to about $34,500 in fiscal year 1961. During the same fiscal year 1958 to fiscal year 1961 period the average value of the research proposals received will increase from $34,700 in fiscal year 1958 to an estimated $45,000 in fiscal year 1960 and to $50,000 in fiscal year 1961.

Another factor which accentuates the need for larger research appropriations is the increasing number of requests for renewed support being received from investigators who have received Foundation support previously. While renewal requests are carefully reviewed in competition with all of the proposals received, they are usually granted continued support because of the established scientific value of the research that has been and will be conducted. As a consequence, with limited funds at its disposal, the Foundation is not able to support as much of the new research proposed as it should. Furthermore, a greater percentage, from 75 to 85 percent, of the amount requested is usually granted for renewal support, whereas about 50 to 60 percent of the amount requested is generally awarded new research applications.

Over and above the production of valuable scientific knowledge, the Foundation's research support programs make a significant contribution to the training of predoctoral and postdoctoral graduate students. Each grant, on the average, supports assistantships on a part-time basis for a number of graduate students and postdoctoral research associates. During fiscal year 1959, about 3,100 research assistants and 1,500 research associates received stipends as part of research grants. In fiscal year 1960, about 4,450 research assistants and 2,250 research associates will receive stipends and training and during fiscal year 1961 it is estimated that about 5,250 research assistants and 2,600 research associates will benefit from the research grants made.

Included in the total amount requested are funds for the support of research in the Antarctic in the amount of $5.5 million and $2 million for the weather modification research program.

Each of the basic research programs is explained in detail in the following text:

Mr. THOMAS. You request an increase of $11,732,884 over last year. It brings you to a total of $78,800,000.

The increase of $11,732,884, or 17.5 percent over the fiscal year 1960 level of $67,067,116 for basic research is predicated on continued increases in the number and dollar value of requests for research support received in the Foundation.

The significant part about this is the continued increase in the request for research grants.

The following table shows the annual growth. Take a look at this chart, gentlemen; it begins with 1955 and goes through 1961. What is the total number of grants we have now? Do we have a list of the grants and the grantee and the subject matter involved? Will you put that in the record?

Dr. WATERMAN. We shall be glad to, Mr. Chairman. For 1960 we will make an estimated 1,895 grants, and the estimate for 1961 is 2,065. This includes the biological and medical sciences, mathematical, physical, social science research, but excludes the Antarctic research program and the program weather modification.

GRANTS AWARDED IN SUPPORT OF SCIENCE AND SCIENTIFIC MANPOWER

Mr. YATES. The grants to which chairman referred and to which you are responding are listed in the document which is headed "Grants awarded by the National Science Foundation in support of science and in support of scientific manpower to universities and other nonprofit institutions during fiscal year 1959."

Dr. WATERMAN. That is right.

Mr. YATES. How many have you made to date?

Dr. WATERMAN. An estimated 1,895 in this category of research for fiscal year 1960.

Mr. YATES. The document may go into the record at this point.

(The document referred to starts on p. 44 ff.)

BIOLOGICAL AND MEDICAL SCIENCES

Dr. WATERMAN. Page 22 has subdivisions by subject.

Mr. YATES. Put page 22 into the record.

Dr. WATERMAN. Physical sciences are described similarly, following page 34—mathematical, physical, and engineering sciences.

Mr. YATES. I think we should put pages 23, 24, 25, 26, 27, 28, 29, and 30 into the record.

I was thinking as I read this last night how very interesting some of these experiments are and how profitable they might be to somebody reading the record.

Dr. WATERMAN. This is a very good summary.

Mr. YATES. Let pages 21 through 33, inclusive, go into the record at this point.

(The pages referred to are as follows:)

BIOLOGICAL AND MEDICAL SCIENCES, $28,150,000

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Program total	$19,805,483	$24,405,177	$28,150,000

The biological and medical sciences program supports basic research by means of grants to all areas of the life sciences. It is estimated that research proposals totaling about $75 million will be received in the Biological and Medical Sciences Division during fiscal year 1961. This is an increase of about $10 million over fiscal year 1960 proposal receipts and is about $23 million over the fiscal year 1959 receipt level. The amount requested will enable the Foundation to support about 38 percent of the dollar value of the expected proposal receipt total.

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Value of proposals received	$52,026,100	$65,000,000	$75,000,000
Value of proposals supported	19,805,483	24,405,177	28,150,000
Value of proposals not supported	32,220,617	40,594,823	46,850,000
Percentage of dollar value of proposals supported	38.1	37.5	37.5

The table following shows the comparative level of proposals received and grants awarded in each of the program areas of the biological and medical sciences.

The increased number and the increased total dollar value of proposals to conduct research received in the biological and medical sciences result from a number of factors. First, and fundamentally, there is a continuing increase in the number of requests coming both from younger scientists who have been supported under various training programs as well as new requests being received from established scientists who have not had Foundation support in the past.

Grants Awarded by the National Science Foundation in Support of Science and in Support of Scientific Manpower to Universities and Other Nonprofit Institutes During Fiscal Year 1959

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Ala.	Alabama College			2	$71,470			2	$71,470
	Alabama Polytechnic Institute	2	$20,300	1	146,200			3	166,500
	Birmingham Southern College			1	55,500			1	55,500
	Spring Hill College			1	23,400			1	23,400
	Tuskegee Institute			3	305,700	1	$15,000	4	320,700
	University of Alabama	1	4,140	2	119,920			3	124,060
	State Total	3	24,440	10	722,190	1	15,000	14	761,630
Alaska	University of Alaska	2	164,000	1	72,100	1	12,790	4	248,890
	State Total	2	164,000	1	72,100	1	12,790	4	248,890
Ariz.	Arizona State College	1	28,600	1	60,000			2	88,600
	Arizona State University			4	407,030			4	407,030
	Association of Universities for Research in Astronomy	1	160,000					1	160,000
	University of Arizona	14	447,200	3	95,700	3	60,630	20	603,530
	State Total	16	635,800	8	562,730	3	60,630	27	1,259,160
Ark.	Agricultural, Mechanical and Normal College			1	26,600			1	26,600
	University of Arkansas			1	77,000	1	14,290	2	91,290
	State Total			2	103,600	1	14,290	3	117,890
Cal.	American Society for Engineering Education					1	29,000	1	29,000
	American Society of Zoologists					1	3,500	1	3,500
	Atmospheric Research Group	1	57,100					1	57,100
	Beaudette Foundation for Biological Research	1	8,800					1	8,800
	California Academy of Sciences	2	108,000					2	108,000
	California Arboretum Foundation, Inc.	1	29,900					1	29,900
	California Institute of Technology	27	813,822			1	19,280	28	833,102
	California State Polytechnic College					1	19,750	1	19,750
	Chico State College			1	56,600			1	56,600
	City of Hope Medical Center	3	67,600					3	67,600
	Claremont College			1	48,400			1	48,400

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower: Teachers' Institutes		Support of Scientific Manpower: Other than Institutes		Total	
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Cal. (Cont'd)	College of the Holy Names					1	$13,290	1	$13,290
	College of Medical Evangelists	1	$12,000					1	12,000
	College of the Pacific			1	$10,040	2	11,350	3	21,390
	Fresno State College			1	108,400			1	108,400
	Harvey Mudd College					1	6,500	1	6,500
	Humboldt State College			1	48,700	1	20,000	2	68,700
	Immaculate Heart College			3	57,620	2	9,900	5	67,520
	Kaiser Foundation	1	8,500					1	8,500
	LaVerne College					1	4,810	1	4,810
	Long Beach State College	2	31,500	1	8,540			3	40,040
	Los Angeles County Museum	1	10,000					1	10,000
	Loyola University of Los Angeles			1	36,100	1	3,150	2	39,250
	Marshall, Royal R.	1	9,600					1	9,600
	Pomona College	2	20,800			2	20,570	4	41,370
	Rancho Santa Ana Botanic Garden	1	7,100					1	7,100
	Sacramento State College	1	7,500	2	66,270			3	73,770
	San Diego State College	1	10,800	1	276,200			2	287,000
	San Jose State College	1	20,600	5	152,690			6	173,290
	Santa Barbara College			1	37,100			1	37,100
	Scripps Clinic & Research Foundation	1	23,000					1	23,000
	Stanford University	35	1,092,863			2	82,260	37	1,175,123
	Stanford University, Hopkins Marine Station			1	18,600			1	18,600
	Tinkham, Ernest R.	1	350					1	350
	University of California	114	3,481,814	12	670,320	13	268,900	139	4,421,034
	University of Redlands			2	47,880	2	12,040	4	59,920
	University of San Francisco	1	15,000			1	1,830	2	16,830
	University of Santa Clara			2	50,500	1	14,490	3	64,990
	University of Southern California	17	271,800	3	124,300	1	15,910	21	412,010
	Whittier College					1	1,150	1	1,150
	State Total	216	6,108,449	39	1,818,260	36	557,680	291	8,484,389
Colo.	Colorado College			1	78,150	2	13,190	3	91,340
	Colorado State College of Education			3	22,270			3	22,270
	Colorado State University			2	96,880	3	42,720	5	139,600
	Colorado State University Research Foundation	6	122,450					6	122,450
	Colorado-Wyoming Academy of Science					1	3,250	1	3,250

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Colo. (Cont'd)	Fort Lewis Agricultural and Mechanical College			2	$83,280			2	$83,280
	High Altitude Observatory	2	$90,600					2	90,600
	University of Colorado	8	258,760	5	467,430	4	$68,460	17	794,650
	University of Denver			3	199,200	3	53,790	6	252,990
	Western State College of Colorado			1	27,100	1	4,830	2	31,930
	State Total	16	471,810	17	974,310	14	186,240	47	1,632,360
Conn.	Connecticut Agricultural Experiment Station	1	8,100					1	8,100
	Connecticut College	1	15,100					1	15,100
	New England Institute for Medical Research					2	2,900	2	2,900
	Saint Joseph College					1	3,050	1	3,050
	Teachers' College of Connecticut			1	48,700			1	48,700
	Trinity College	2	17,550			1	21,950	3	39,500
	University of Bridgeport					1	23,950	1	23,950
	University of Connecticut	6	97,300	2	124,850	2	17,560	10	239,710
	Wesleyan University	5	71,400	1	100,000			6	171,400
	Yale University	38	1,437,200	3	132,750	4	1,280,730	45	2,850,680
	State Total	53	1,646,650	7	406,300	11	1,350,140	71	3,403,090
Del.	University of Delaware	8	206,600	2	46,200	1	11,500	11	264,300
	State Total	8	206,600	2	46,200	1	11,500	11	264,300
D. C.	American Association for the Advancement of Science					2	800,000	2	800,000
	American Association of Junior Colleges					1	28,100	1	28,100
	American Astronomical Society					1	38,115	1	38,115
	American Chemical Society					2	143,000	2	143,000
	American Geological Institute					3	143,180	3	143,180
	American Institute of Biological Sciences					4	854,760	4	854,760
	American Physiological Society	1	74,500			4	44,690	5	119,190
	American Psychological Association					1	17,300	1	17,300
	American University	1	9,600	3	126,740	1	2,540	5	138,880
	Bureau of Social Science Research					1	101,700	1	101,700
	Carnegie Institute of Washington	1	9,569					1	9,569

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

4.

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
D. C. (Cont'd)	Catholic University of America	5	$43,100	2	$76,800	1	$14,260	8	$134,160
	Department of Agriculture, U. S. Forest Service					1	2,400	1	2,400
	Department of Health, Education and Welfare, Office of Education					1	18,000	1	18,000
	Federation of American Societies for Experimental Biology					1	10,000	1	10,000
	Georgetown University	4	79,540	1	27,600	1	14,500	6	121,640
	George Washington University	4	54,375	1	3,400			5	57,775
	The Greater Washington Educational Television Association, Inc.					1	15,900	1	15,900
	Howard University	2	33,000	1	52,000	3	62,950	6	147,950
	The Library of Congress					1	2,000	1	2,000
	National Academy of Sciences-National Research Council	3	55,840			11	159,425	14	215,265
	National Bureau of Standards	7	372,763					7	372,763
	The National 4-H Club Foundation					1	9,545	1	9,545
	National Science Teachers Association					3	27,900	3	27,900
	Office of Civil and Defense Mobilization, Executive Office of the President					1	6,000	1	6,000
	Office of Naval Research	2	300,000					2	300,000
	Research Foundation of Childrens' Hospital	1	14,000					1	14,000
	Science Service					1	50,000	1	50,000
	Smithsonian Institution	6	128,900					6	128,900
	Surveys and Research Corporation					1	21,870	1	21,870
	U. S. Coast and Geodetic Survey	5	128,000					5	128,000
	U. S. Department of Labor, Bureau of Labor Statistics					4	215,000	4	215,000
	U. S. Geological Survey	5	408,000					5	408,000
	U. S. Weather Bureau	8	1,534,941					8	1,534,941
	Washington Academy of Sciences					1	35,250	1	35,250
	State Total	55	3,246,128	8	266,540	53	2,838,385	116	6,371,053
Fla.	Cape Haze Marine Laboratory	1	1,800					1	1,800
	Florida Agricultural and Mechanical University					1	4,250	1	4,250

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Fla. (Cont'd)	Florida State University	13	$263,000	5	$297,120	2	$20,840	20	$580,960
	Marine Laboratory	1	20,000					1	20,000
	Stetson University					1	23,140	1	23,140
	University of Florida	9	228,000	1	112,400	2	30,440	12	370,840
	University of Miami	13	368,980	1	14,070	2	10,110	16	393,160
	State Total	37	881,780	7	423,590	8	88,780	52	1,394,150
Ga.	Atlanta University			2	303,800			2	303,800
	Emory University	3	69,200	3	60,080	1	11,450	7	140,730
	Georgia Institute of Technology	11	1,093,900					11	1,093,900
	Mercer University	1	2,600					1	2,600
	Morris Brown College					1	16,900	1	16,900
	Oglethorpe University	1	20,700					1	20,700
	Shorter College			1	11,500			1	11,500
	University of Georgia	8	111,450	3	347,600			11	459,050
	State Total	24	1,297,850	9	722,980	2	28,350	35	2,049,180
Hawaii	Bernice P. Bishop Museum	1	171,600					1	171,600
	Hawaiian Academy of Science					3	29,660	3	29,660
	University of Hawaii	4	97,500	3	232,000	1	6,810	8	336,310
	State Total	5	269,100	3	232,000	4	36,470	12	537,570
Ida.	Idaho State College					2	2,550	2	2,550
	Northwest Nazarene College	1	31,500					1	31,500
	University of Idaho	2	4,500	1	64,000			3	68,500
	State Total	3	36,000	1	64,000	2	2,550	6	102,550
Ill.	Bradley University			1	43,000			1	43,000
	The Chicago Academy of Sciences					1	4,190	1	4,190
	Chicago Natural History Museum	3	47,000					3	47,000
	De Paul University	1	11,200					1	11,200
	Eastern Illinois University			1	29,700			1	29,700
	Greenville College	1	17,000					1	17,000
	Illinois College			1	4,330			1	4,330
	Illinois Institute of Technology	8	174,900	2	130,000	3	42,910	13	347,810
	Illinois Wesleyan University			1	71,500			1	71,500
	Knox College			2	58,150	2	13,370	4	71,520
	Lake Forest College			1	6,800			1	6,800

	Miami Valley College			1	6,800			1	6,800

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

6.

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Ill. (Cont'd)	Michael Reese Hospital	1	$20,000					1	$20,000
	Millikin University					1	$1,560	1	1,560
	Mount Sinai Medical Research Foundation	1	39,700					1	39,700
	Northern Illinois University	1	9,600	2	$74,090			3	83,690
	Northwestern University	25	710,800	3	79,960	2	15,200	30	805,960
	Saint Xavier College			1	5,400			1	5,400
	Snow, Ice & Permafrost Research Establishment	2	200,000					2	200,000
	Southern Illinois University	2	27,100	1	64,500	2	23,580	5	115,180
	University of Chicago	30	2,029,850			4	195,520	34	2,225,370
	University of Illinois	44	1,260,000	3	460,700	4	27,300	51	1,748,000
	Wheaton College	1	5,300					1	5,300
	State Total	120	4,552,450	19	1,028,130	19	323,630	158	5,904,210
Ind.	Ball State Teachers College			2	62,750			2	62,750
	Butler University	1	6,000	1	16,080	2	8,670	4	30,750
	De Pauw University			2	71,100			2	71,100
	Earlham College					2	97,320	2	97,320
	Evansville College			1	4,530			1	4,530
	Goshen College	1	11,600					1	11,600
	Hanover College	1	1,500					1	1,500
	Indiana Central College			1	7,020			1	7,020
	Indiana State Teachers College			2	93,600			2	93,600
	Indiana University			4	175,000	5	80,610	9	255,610
	Indiana University Foundation	21	514,500					21	514,500
	Manchester College	1	5,800					1	5,800
	Marian College			1	3,820			1	3,820
	Purdue Research Foundation	28	634,700					28	634,700
	Purdue University			5	284,160	2	29,760	7	313,920
	Saint Joseph's College					1	3,760	1	3,760
	University of Notre Dame	7	201,300	3	400,800	4	17,065	14	619,165
	Valparaiso University	1	1,600					1	1,600
	Wabash College	2	12,000			2	11,520	4	23,520
	State Total	63	1,389,000	22	1,118,860	18	248,705	103	2,756,565
Iowa	Clarke College					1	300	1	300
	Cornell College	2	16,300			2	20,180	4	36,480
	Drake University			3	109,830	1	15,390	4	125,220

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Iowa (Cont'd)	Grinnell College	1	$14,800			1	$14,280	2	$29,080
	Iowa State College of Agriculture and Mechanic Arts			3	$160,800	2	18,270	5	179,070
	Iowa State Teachers College			2	424,000	3	29,700	5	453,700
	Iowa State University	14	381,650					14	381,650
	Loras College					1	3,440	1	3,440
	Luther College	1	3,200					1	3,200
	Marycrest College	1	2,500					1	2,500
	State University of Iowa	13	328,500	2	128,600	7	47,350	22	504,450
	State Total	32	746,950	10	823,230	18	148,910	60	1,719,090
Kans.	Fort Hays Kansas State College			2	113,000			2	113,000
	Kansas State College of Agriculture and Applied Sciences			2	63,610	3	38,520	5	102,130
	Kansas State Teachers College	1	7,000	3	243,300	2	8,620	6	258,920
	Kansas State University	6	122,700					6	122,700
	Saint Mary of the Plains College	1	7,100					1	7,100
	University of Kansas	24	464,500	4	462,300	3	46,430	31	973,230
	University of Wichita	1	9,750			1	3,490	2	13,240
	Washburn University of Topeka			1	63,800			1	63,800
	State Total	33	611,050	12	946,010	9	97,060	54	1,654,120
Ky.	Kentucky Research Foundation	3	96,300			1	28,230	4	124,530
	Morehead State College			1	60,050			1	60,050
	Murray State College			2	91,600			2	91,600
	Nazareth College	1	3,000					1	3,000
	University of Louisville	3	58,780	1	3,500			4	62,280
	Western Kentucky State College			2	88,230	2	29,950	4	118,180
	State Total	7	158,080	6	243,380	3	58,180	16	459,640
La.	Alton Ochsner Medical Foundation	1	20,000					1	20,000
	Dillard University			1	38,500			1	38,500
	Louisiana Polytechnic Institute	1	8,800			1	19,710	2	28,510
	Louisiana State University	5	100,500					5	100,500
	Louisiana State University and Agricultural and Mechanical College			3	335,850	3	51,840	6	387,690
	Loyola University	1	6,500					1	6,500
	Northeast Louisiana State College	1	4,000					1	4,000
	Northwestern State College of Louisiana			2	146,800	2	4,770	4	151,570

Louisiana		2	146,800	2	4,770	4	151,570

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

8.

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
La. (Cont'd)	Southern University and Agricultural and Mechanical College			2	$40,450	1	$1,620	3	$42,070
	Southwestern Louisiana Institute			2	92,330			2	92,330
	Tulane University of Louisiana	9	$267,300			1	18,100	10	285,400
	State Total	18	407,100	10	653,930	8	96,040	36	1,157,070
Me.	Bowdoin College			6	188,150	1	8,650	7	196,800
	Colby College			1	78,700			1	78,700
	Roscoe B. Jackson Memorial Laboratory	3	261,000			1	12,140	4	273,140
	University of Maine	1	4,700	1	48,600	1	42,780	3	96,080
	State Total	4	265,700	8	315,450	3	63,570	15	644,720
Md.	College of Notre Dame of Maryland					1	3,700	1	3,700
	Goucher College	4	67,800			1	1,340	5	69,140
	Johns Hopkins University	26	1,113,000	1	10,200	3	72,300	30	1,195,500
	Maryland Academy of Science					2	28,740	2	28,740
	Morgan State College			1	73,700	1	17,500	2	91,200
	University of Maryland	13	181,450	3	136,460	4	32,170	20	350,080
	State Total	43	1,362,250	5	220,360	12	155,750	60	1,738,360
Mass.	American Academy of Arts and Sciences					1	33,570	1	33,570
	American Association of Variable Star Observers	1	575					1	575
	American Meteorological Society					3	131,640	3	131,640
	American Society for Engineering Education					1	18,325	1	18,325
	Amherst College	2	43,000			1	18,870	3	61,870
	Assumption College					1	15,600	1	15,600
	Boston College	1	16,300	5	296,150			6	312,450
	Boston University	8	120,380			3	41,390	11	161,770
	Botanical Museum of Harvard University	1	5,100					1	5,100
	Brandeis University	15	430,000	1	19,500	1	7,490	17	456,990
	Clark University	1	4,200	1	65,900			2	70,100
	College of the Holy Cross			2	65,250			2	65,250
	Eastern Nazarene College					1	2,670	1	2,670

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Mass. (Cont'd)	Emanuel College					1	$4,400	1	$4,400
	Genetics Society of America	1	$12,000					1	12,000
	Harvard University	38	1,137,200	1	$280,400	3	25,172	42	1,442,772
	Harvard University Herbarium	1	23,400					1	23,400
	L.G. Hanscomb Air Force Base	2	21,320					2	21,320
	Marine Biological Laboratory	4	196,000					4	196,000
	Massachusetts General Hospital	1	21,000					1	21,000
	Massachusetts Institute of Technology	32	1,910,125			5	3,200,250	37	5,110,375
	Massachusetts State Teachers College			2	13,990			2	13,990
	Mount Holyoke College	2	15,900					2	15,900
	Northeastern University					1	8,600	1	8,600
	Simmons College			1	24,400			1	24,400
	Smith College	2	55,000					2	55,000
	Tufts University	8	273,770	1	52,200	3	47,330	12	373,300
	University of Massachusetts	3	43,300	3	133,975	2	20,560	8	197,835
	Wellesley College	1	10,800					1	10,800
	Williams College	3	27,300	1	7,180			4	34,480
	Woods Hole Oceanographic Institution	13	1,145,300			1	11,500	14	1,156,800
	Worcester Foundation for Experimental Biology	3	105,000			1	20,870	4	125,870
	Worcester Polytechnic Institute	1	12,700	3	165,500			4	178,200
	State Total	144	5,629,670	21	1,124,445	29	3,608,237	194	10,362,352
Mich.	Albion College	2	12,800					2	12,800
	Central Michigan College			2	57,800			2	57,800
	Cranbrook Institute of Science					1	1,100	1	1,100
	Eastern Michigan College			3	79,900			3	79,900
	Junior Engineering Technical Society, Inc.					1	16,680	1	16,680
	Marygrove College			1	5,250			1	5,250
	Michigan College of Mining and Technology					3	19,490	3	19,490
	Michigan State University	22	650,700					22	650,700
	Michigan State University of Agriculture and Applied Science			3	194,300	6	454,260	9	648,560
	Northern Michigan College			1	54,500	1	16,500	2	71,000

	Northern Michigan College.....			1	54,500	1	16,500	2	71,000

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

10.

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Mich. (Cont'd)	University of Detroit.....			2	$60,050	3	$24,600	5	$84,650
	University of Michigan.....	28	$508,550	4	347,300	8	104,000	40	959,850
	Wayne State University.....	14	213,380	4	98,810	2	17,620	20	329,810
	Western Michigan University.....			3	112,550	4	53,510	7	166,060
	State Total.....	66	1,385,430	23	1,010,460	29	707,760	118	3,103,650
Minn.	Augsburgh College & Theological Seminary.....	1	5,100					1	5,100
	Carleton College.....	4	50,100	1	142,700	1	12,200	6	205,000
	College of St. Benedict.....			1	9,480			1	9,480
	College of St. Catherine.....			1	4,100	1	2,970	2	7,070
	College of St. Thomas.....			2	57,920			2	57,920
	Concordia College.....			1	17,230			1	17,230
	Gustavus Adolphus College.....					1	910	1	910
	Macalester College.....			1	43,500	1	960	2	44,460
	Mankato State College.....			1	43,700	1	7,980	2	51,680
	Mayo Association.....	2	96,000					2	96,000
	Minneapolis War Memorial Blood Bank	1	40,000					1	40,000
	Saint Cloud State College.....					1	14,920	1	14,920
	Saint Mary's College.....					2	17,950	2	17,950
	Saint Olaf College.....	1	27,600			1	34,740	2	62,340
	University of Minnesota.....	44	1,166,791	6	592,000	4	71,790	54	1,830,581
	State Total.....	53	1,385,591	14	910,630	13	164,420	80	2,460,641
Miss.	Millsaps College.....					1	3,070	1	3,070
	Mississippi Academy of Sciences, Inc.....					1	38,820	1	38,820
	Mississippi College.....			1	26,440			1	26,440
	Mississippi Southern College.....			1	80,800	1	12,500	2	93,300
	Mississippi State College.....			1	151,800	1	6,810	2	158,610
	Tougaloo Southern Christian College			1	13,200			1	13,200
	University of Mississippi.....	2	25,750	2	167,050			4	192,800
	State Total.....	2	25,750	6	439,290	4	61,200	12	526,240
Mo.	Academy of Science of St. Louis....					1	17,760	1	17,760
	Lincoln University.....	1	8,600					1	8,600
	Midwest Research Institute.....					2	12,070	2	12,070
	Missouri Botanical Garden.....	3	50,500	1	3,030			4	53,530

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

11.

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Mo. (Cont'd)	Northeast Missouri State Teachers College			1	$87,100			1	$87,100
	Saint Louis University	4	$60,230	4	99,550	3	$12,930	11	172,710
	Southwest Missouri State College	1	7,300	1	26,800			2	34,100
	University of Missouri	13	294,950	4	239,060	1	17,600	18	551,610
	Washington University	15	436,000	2	336,150	1	2,015	18	774,165
	William Jewell College			2	87,500			2	87,500
	State Total	37	857,580	15	879,190	8	62,375	60	1,799,145
Mont.	Eastern Montana College of Education					1	2,100	1	2,100
	Montana State College	6	73,600	2	83,900	1	23,250	9	180,750
	Montana State University	1	23,700	5	175,600	5	47,640	11	246,940
	State Total	7	97,300	7	259,500	7	72,990	21	429,790
Nebr.	Nebraska State Teachers College	1	11,000					1	11,000
	Nebraska Wesleyan University	1	7,300					1	7,300
	University of Nebraska	5	60,000	1	64,400			6	124,400
	State Total	7	78,300	1	64,400			8	142,700
Nev.	University of Nevada	2	36,300	1	57,400			3	93,700
	State Total	2	36,300	1	57,400			3	93,700
N.H.	Dartmouth College	13	191,550	1	11,200	1	17,300	15	220,050
	New Hampshire Academy of Science					1	6,115	1	6,115
	Rivier College			1	24,600			1	24,600
	University of New Hampshire	3	24,300	1	80,600	1	7,780	5	112,680
	State Total	16	215,850	3	116,400	3	31,195	22	363,445
N.J.	College of Saint Elizabeth					1	4,630	1	4,630
	Educational Testing Service					1	41,500	1	41,500
	Institute for Advanced Study	2	138,000					2	138,000
	Montclair State College			2	83,730			2	83,730
	Newark College of Engineering					2	18,970	2	18,970
	Newark State College	1	13,000					1	13,000
	Princeton University	6	345,250	3	82,180	1	14,430	10	441,860
	Rutgers University	18	444,950	7	236,240	1	14,210	26	695,400
	Seton Hall University	1	10,350					1	10,350
	Stevens Institute of Technology	2	49,500	2	72,930			4	122,430
	Training School at Vineland	1	14,400					1	14,400
	State Total	31	1,015,450	14	475,080	6	93,740	51	1,584,270

Training School at Vineland	1	14,400					1	14,400
State Total	31	1,015,490	14	475,080	6	93,740	51	1,584,270

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower					
				Teachers' Institutes		Other than Institutes		Total	
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
N. Mex.	New Mexico College	1	$21,600					1	$21,600
	New Mexico College of Agriculture and Mechanic Arts			1	$133,000	1	$18,360	2	151,360
	New Mexico Highlands University	1	10,400	1	62,700	2	27,470	4	100,570
	New Mexico Institute of Mining and Technology	3	248,400			4	38,480	7	286,880
	University of New Mexico	4	91,300	3	302,400	2	37,630	9	431,330
	State Total	9	371,700	5	498,100	9	121,940	23	991,740
N.Y.	Adelphi College	1	13,300	1	96,400	1	5,900	3	115,600
	Alfred University			1	43,700			1	43,700
	American Association of Physics Teachers					1	8,620	1	8,620
	American Chemical Society					1	2,200	1	2,200
	American Geographical Society	4	53,693					4	53,693
	American Institute of Physics					6	179,270	6	179,270
	American Museum of Natural History	13	182,100	1	12,300	2	22,710	16	217,110
	Arctic Institute of North America	10	519,742					10	519,742
	Association of Laboratory Teachers					1	1,000	1	1,000
	Barnard College					1	9,040	1	9,040
	Boyce Thompson Institute for Plant Research	2	70,700					2	70,700
	Brooklyn Botanic Garden	1	31,300					1	31,300
	Brooklyn College	2	33,300	4	106,000			6	139,300
	Buffalo Society of Natural Sciences					1	19,480	1	19,480
	Canisius College					1	5,330	1	5,330
	City College	1	7,500			2	12,605	3	20,105
	Clarkson College of Technology	1	12,600	1	76,500	1	17,440	3	106,540
	Colgate College	1	8,700					1	8,700
	Colgate University			1	48,200	2	28,820	3	77,020
	College of New Rochelle	1	4,400					1	4,400
	Columbia University	40	1,263,187					40	1,263,187
	Columbia University Teachers College			2	49,320	1	33,800	3	83,120
	The Cooper Union for the Advancement of Science and Art					2	19,600	2	19,600
	Cornell University	36	1,493,000	1	53,800	3	91,920	40	1,638,720
	Creedmore Institute of Psychobiologic Studies Branch (Research Foundation for Mental Hygiene, Inc.)					1	1,790	1	1,790

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
N.Y. (Cont'd)	Engineers Joint Council					3	$54,398	3	$54,398
	Fordham University	8	$170,100	2	$105,150	1	9,390	11	284,640
	Hamilton College	1	10,600	1	64,500			2	75,100
	Hunter College of the City of New York			2	95,900	2	10,760	4	106,660
	Institute of Andean Research	1	40,700					1	40,700
	Isaac Albert Research Institute	1	29,300					1	29,300
	Long Island Biological Association					2	20,100	2	20,100
	Long Island Biological Institute	2	161,000					2	161,000
	Manhattan College	2	26,100	1	6,300	2	21,070	5	53,470
	The Mathematical Association of America					5	271,000	5	271,000
	Mount Sinai Hospital	2	42,000					2	42,000
	National Bureau of Economic Research, Inc	1	51,000					1	51,000
	New York Botanical Garden	8	285,200			1	14,750	9	299,950
	New York State Socity for Medical Research, Inc					1	7,500	1	7,500
	New York University	17	473,900	2	21,420	6	46,370	25	541,690
	New York Zoological Society	3	57,400					3	57,400
	Pace College			1	5,630			1	5,630
	Polytechnic Institute of Brooklyn	4	238,000			1	9,190	5	247,190
	Pratt Institute	1	10,200	1	36,300			2	46,500
	Queens College	2	35,300					2	35,300
	Rensselaer Polytechnic Institute	6	126,000	2	372,700	4	49,140	12	547,840
	Research Foundation of State University of New York	14	170,235					14	170,235
	Rochester Museum of Arts and Sciences					1	715	1	715
	Rockefeller Institute	7	101,900			1	24,150	8	126,050
	Roswell Park Memorial Institute					1	7,050	1	7,050
	Saint John's University					1	11,810	1	11,810
	Saint Lawrence University	1	13,600					1	13,600
	Sarah Lawrence College			2	49,700			2	49,700
	State University of New York College of Forestry					1	8,500	1	8,500
	State University of New York Teachers College			5	208,330			5	208,330
	Syracuse University Research Institute	11	216,300	5	436,850	4	73,885	20	727,035
	Teachers College - Columbia University	1	12,100					1	12,100

	Teachers College - Columbia University	1	12,100					1	12,100

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower					
				Teachers' Institutes		Other than Institutes		Total	
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
N.Y. (Cont'd)	Union College	1	$8,280					1	$8,280
	Union College and University			2	$165,200	1	$5,690	3	170,890
	University of Buffalo	6	485,700	2	44,830	1	6,380	9	536,910
	University of Rochester	6	118,400	2	93,400	1	19,920	9	231,720
	Waldemar Medical Research Foundation, Inc.					2	21,110	2	21,110
	Yeshiva University	3	101,400	1	17,680	1	13,290	5	132,370
	State Total	222	6,678,237	43	2,210,110	70	1,165,693	335	10,054,040
N.C.	Agricultural and Technical College of North Carolina			1	50,900	2	25,340	3	76,240
	Appalachian State Teachers College					1	21,400	1	21,400
	Bennet College					1	40,570	1	40,570
	Duke University	20	591,026	3	146,700	1	11,750	24	749,476
	East Carolina College			1	59,200	1	8,080	2	67,280
	The Highlands Biological Statation					1	4,350	1	4,350
	North Carolina Academy of Science			1	19,970			1	19,970
	North Carolina College at Durham			2	123,400	1	15,440	3	138,840
	North Carolina State College	8	196,600					8	196,600
	North Carolina State College of Agriculture and Engineering			2	36,300	5	225,450	7	261,750
	Pfeiffer College	1	2,000					1	2,000
	Saint Augustine's College			2	57,640	1	11,250	3	68,890
	Shaw University			1	6,100			1	6,100
	University of North Carolina	9	684,460	4	437,750	3	48,410	16	1,170,620
	Wake Forest College			1	58,800			1	58,800
	Western Carolina College	1	6,000					1	6,000
	Woman's College of the University of North Carolina			2	69,600			2	69,600
	State Total	39	1,480,086	20	1,066,360	17	412,040	76	2,958,486
N. D.	North Dakota Agricultural College	1	20,000	1	95,000	2	29,840	4	144,840
	University of North Dakota	3	36,710	2	316,980	3	12,410	8	366,100
	State Total	4	56,710	3	411,980	5	42,250	12	510,940
Ohio	Antioch College	1	12,700	2	106,600			3	119,300
	Baldwin Wallace College			1	57,400			1	57,400
	Bowling Green State University			1	12,450	1	3,300	2	15,750
	Case Institute of Technology	4	92,800	4	128,260	3	47,880	11	268,940

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower: Teachers' Institutes		Support of Scientific Manpower: Other than Institutes		Total	
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Ohio (Cont'd)	College of Wooster					2	$22,070	2	$22,070
	Columbus Psychiatric Institute and Hospital	1	$8,600					1	8,600
	Defiance College					1	8,500	1	8,500
	Dennison University	1	6,900					1	6,900
	Fenn College			1	$6,700			1	6,700
	Hiram College			1	6,100	1	4,250	2	10,350
	Jewish Hospital and Medical Center	1	22,600					1	22,600
	Kent State University	1	2,400	2	133,700			3	136,100
	Kenyon College					1	480	1	480
	May Institute for Medical Research	1	21,000					1	21,000
	Miami University	2	25,700	2	69,030	1	9,130	5	103,860
	Oberlin College	3	48,000	1	126,400	1	42,100	5	216,500
	Ohio Academy of Science	1	23,900			1	750	2	24,650
	Ohio State University			3	456,250	3	33,530	6	489,780
	Ohio State University Research Foundation	19	600,122					19	600,122
	Ohio University	4	67,300	3	105,130	2	26,370	9	198,800
	Ohio Wesleyan University	1	20,400	1	46,900	2	5,590	4	72,890
	University of Akron	1	56,000	1	8,830			2	64,830
	University of Cincinnati	9	168,610	1	51,500	1	3,210	11	223,320
	University of Dayton	1	4,800					1	4,800
	University of Toledo	1	22,800	2	68,480			3	91,280
	Western Reserve University	6	149,160	1	128,600	1	19,180	8	296,940
	Wittenberg College			1	44,600			1	44,600
	Xavier University			2	46,420	1	6,410	3	52,830
	State Total	58	1,353,792	30	1,603,350	22	232,750	110	3,189,892
Okla.	Central State College			1	3,680			1	3,680
	Oklahoma Academy of Science					2	34,600	2	34,600
	Oklahoma Baptist University			1	54,300	1	5,400	2	59,700
	Oklahoma Medical Research Foundation	1	31,000					1	31,000
	Oklahoma State University of Agriculture and Applied Science			5	444,230	6	395,150	11	839,380
	Research Foundation, Oklahoma State University	5	73,700					5	73,700
	Southeastern State College	1	16,400	1	13,150	1	3,710	3	33,260

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Okla. (Cont'd)	University of Oklahoma			6	$199,560	3	$72,440	9	$272,000
	University of Oklahoma Research Institute	11	$301,300					11	301,300
	University of Tulsa	1	12,600			1	3,600	2	16,200
	State Total	19	435,000	14	714,920	14	514,900	47	1,664,820
Ore.	Linfield Research Institute	3	121,900					3	121,900
	Marylhurst College			1	5,180			1	5,180
	The Oregon Museum of Science and Industry					1	4,990	1	4,990
	Oregon State College	11	196,800	6	563,100	11	73,490	28	833,390
	Portland State College	1	4,900	1	67,400			2	72,300
	Reed College	3	25,300	4	123,350	2	46,700	9	195,350
	University of Oregon	16	278,260	3	102,620	2	427,870	21	808,750
	State Total	34	627,160	15	861,650	16	553,050	65	2,041,860
Pa.	Academy of Natural Science of Philadelphia	3	113,200					3	113,200
	Albright College			1	6,720	1	1,780	2	8,500
	Allegheny College			1	77,300	1	6,060	2	83,360
	Bryn Mawr College	1	3,000	1	10,160	1	8,250	3	21,410
	Bucknell University	1	2,800	3	72,970	3	19,250	7	95,020
	Carnegie Institute of Technology	7	179,000			1	25,940	8	204,940
	Carnegie Museum	1	7,500					1	7,500
	Children's Hospital of Philadelphia	1	34,000					1	34,000
	Dickenson College	2	28,300					2	28,300
	Drexel Institute of Technology					1	9,460	1	9,460
	Duquesne University	4	55,700			1	2,200	5	57,900
	Eastern Pennsylvania Psychiatric Institute	1	30,000					1	30,000
	Franklin and Marshall College	1	11,400	2	85,000	1	5,590	4	101,990
	Franklin Institute	2	47,200					2	47,200
	Geneva College			1	10,570	2	7,425	3	17,995
	Grove City College					1	780	1	780
	Hahnemann Medical College and Hospital	1	28,750					1	28,750
	Haverford College	1	11,800	1	8,140			2	19,940
	Immaculata College			1	10,000			1	10,000

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Pa. (Cont'd)	Institute for Cancer Research	2	$57,000					2	$57,000
	Jefferson Medical College	1	8,280					1	8,280
	Juniata College					1	$8,160	1	8,160
	King's College					1	3,750	1	3,750
	Lafayette College	1	4,500	1	$52,500	1	11,360	3	68,360
	Lehigh University	4	109,000	1	39,900	2	7,100	7	156,000
	Lincoln University			1	9,430			1	9,430
	Mellon Institute of Industrial Research	3	111,200					3	111,200
	Mount Mercy College			3	11,500	1	4,060	4	15,560
	Muhlenberg College			1	33,500			1	33,500
	Pennsylvania State University	20	510,410	5	474,650	1	15,430	26	1,000,490
	Philadelphia College of Pharmacy and Science			1	27,400			1	27,400
	Research Institute of Temple University	2	66,720					2	66,720
	Rosemont College					1	2,085	1	2,085
	Seton Hill College			1	38,600			1	38,600
	Shippensburg State Teachers College			1	30,100			1	30,100
	Society for Industrial and Applied Mathematics					1	12,130	1	12,130
	Swarthmore College	2	46,500					2	46,500
	Temple University			3	118,590	1	19,100	4	137,690
	Thiel College			1	28,500			1	28,500
	University of Pennsylvania	24	605,500	3	385,120	3	12,780	30	1,003,400
	University of Pittsburgh	13	310,920	2	65,200	1	8,500	16	384,620
	University of Scranton			2	7,990			2	7,990
	Ursinus College	1	2,000					1	2,000
	Villanova University			2	120,200	1	4,070	3	124,270
	Wilkes College	1	8,500	1	2,920			2	11,420
	Wilson College	1	18,500					1	18,500
	Wistar Institute of Anatomy and Biology	1	80,000					1	80,000
	Woman's Medical College of Pennsylvania	1	8,280					1	8,280
	Zoological Society of Philadelphia	1	10,300					1	10,300
	State Total	104	2,510,260	40	1,726,960	28	195,260	172	4,432,480

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

18.

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower					
				Teachers' Institutes		Other than Institutes		Total	
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
R. I.	American Mathematical Society	1	$41,000			1	$25,600	2	$66,600
	Brown University	12	298,200	3	$399,200	1	17,130	16	714,530
	University of Rhode Island	2	9,300	1	30,200			3	39,500
	State Total	15	348,500	4	429,400	2	42,730	21	820,630
S. C.	Benedict College			1	50,900			1	50,900
	Clemson Agricultural College	1	11,500	1	50,600			2	62,100
	Columbia College			1	49,200			1	49,200
	Converse College			1	77,500			1	77,500
	Furman University					1	12,330	1	12,330
	University of South Carolina			2	111,250	2	22,870	4	134,120
	State Total	1	11,500	6	339,450	3	35,200	10	386,150
S. Dak.	Northern State Teachers College			1	25,000			1	25,000
	South Dakota Academy of Science					1	18,560	1	18,560
	South Dakota School of Mines and Technology			1	167,700	1	4,790	2	172,490
	South Dakota State College of Agriculture and Mechanic Arts			2	73,780	2	23,560	4	97,340
	South Dakota State Geological Survey	1	5,400					1	5,400
	State University of South Dakota			3	386,570	3	35,210	6	421,780
	State Total	1	5,400	7	653,050	7	82,120	15	740,570
Tenn.	East Tennessee State College			1	57,200			1	57,200
	Fisk University			3	138,040	1	1,360	4	139,400
	George Peabody College for Teachers			1	136,900	1	51,700	2	188,600
	Knoxville College			1	16,040	1	27,360	2	43,400
	Memphis State University			1	38,500			1	38,500
	Middle Tennessee State College			2	77,450			2	77,450
	The Oak Ridge Institute of Nuclear Studies (Atomic Energy Commission)			1	33,200	3	547,600	4	580,800
	Southwestern at Memphis			1	5,430	1	6,250	2	11,680
	Tennessee Academy of Science			1	15,670			1	15,670
	Tennessee Agricultural and Industrial State University			1	10,080			1	10,080
	Tennessee Polytechnic Institute			2	107,520	1	6,550	3	114,070
	University of Chattanooga			2	73,620			2	73,620
	University of Tennessee	8	83,230			4	34,580	12	117,810
	Vanderbilt University	7	185,900	2	135,000			9	320,900
	State Total	15	269,130	19	844,650	12	675,400	46	1,789,180

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Tex.	Agricultural and Mechanical College of Texas			2	$148,600	3	$38,260	5	$186,860
	Baylor University			2	96,600			2	96,600
	Bishop College			1	14,540			1	14,540
	East Texas State College			5	45,760	1	5,940	6	51,700
	Howard Payne College			1	49,400	1	7,700	2	57,100
	Incarnate Word College			1	8,950			1	8,950
	Lamar State College					1	6,400	1	6,400
	Lubbock Christian College	1	$4,600					1	4,600
	North Texas State College			2	54,540			2	54,540
	Our Lady of the Lake College			1	33,600			1	33,600
	Pan American College	1	9,100	1	10,830			2	19,930
	Prairie View Agricultural and Mechanical College			2	56,300	3	15,980	5	72,280
	Rice Institute	7	159,100					7	159,100
	Saint Mary's University of San Antonio					1	7,040	1	7,040
	Southern Methodist University	2	18,400	3	60,900	2	16,380	7	95,680
	Stephen F. Austin State College			1	51,800	1	8,830	2	60,630
	Texas A & M College	2	365,000					2	365,000
	Texas A & M Research Foundation	4	135,500					4	135,500
	The Texas Academy of Science					2	30,940	2	30,940
	Texas Christian University			1	92,400			1	92,400
	Texas College of Arts & Industries	1	15,900					1	15,900
	Texas Lutheran College	1	6,600					1	6,600
	Texas Southern University			1	88,000			1	88,000
	Texas Technological College	2	7,800	2	148,700	1	5,100	5	161,600
	Texas Woman's University			1	9,200	5	28,920	6	38,120
	University of Houston	2	43,400	2	66,060			4	109,460
	University of Saint Thomas	1	5,800					1	5,800
	University of Texas	23	411,620	4	390,200	6	55,600	33	857,420
	West Texas State College			1	84,500			1	84,500
	State Total	47	1,182,820	34	1,510,880	27	227,090	108	2,920,790
Utah	Brigham Young University	5	163,400	4	111,150	3	41,420	12	315,970
	University of Utah	10	164,800	3	312,650	5	66,145	18	543,595
	Utah State University	2	32,700					2	32,700
	Utah State University of Agriculture and Applied Science			2	84,130			2	84,130
	State Total	17	360,900	9	507,930	8	107,565	34	976,395

culture and Applied Science.....			2	84,130			2	84,130
State Total.....	17	360,900	9	507,930	8	107,565	34	976,395

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

20.

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower: Teachers' Institutes		Support of Scientific Manpower: Other than Institutes		Total	
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Vt.	Goddard College.....					1	$10,140	1	$10,140
	Lyndon State Teachers College....			1	$7,800			1	7,800
	Norwich University.....					1	5,830	1	5,830
	University of Vermont.....	9	$124,180					9	124,180
	University of Vermont and State Agricultural College.....			2	165,200	1	8,720	3	173,920
	State Total.....	9	124,180	3	173,000	3	24,690	15	321,870
Va.	Bridgewater College.....			1	14,710	1	4,200	2	18,910
	College of William and Mary.....	1	53,000	1	53,000			2	106,000
	Emory and Henry College.....					1	4,960	1	4,960
	Hampden-Sydney College.....					1	1,200	1	1,200
	Hampton Institute.....			2	112,000			2	112,000
	Hollins College.....					1	5,700	1	5,700
	Longwood College.....	1	38,600					1	38,600
	Medical College of Virginia.....	1	24,000					1	24,000
	Randolph-Macon Woman's College...			1	61,300			1	61,300
	University of Virginia.....	7	100,320	7	399,800	1	7,770	15	507,890
	Virginia Academy of Science.....					1	6,450	1	6,450
	Virginia Fisheries Laboratory....					2	23,800	2	23,800
	Virginia Polytechnic Institute...			1	81,770	1	8,990	2	90,760
	Virginia State College.....			1	86,550	1	6,650	2	93,200
	State Total.....	10	215,920	14	809,130	10	69,720	34	1,094,770
Wash.	College of Puget Sound.....			1	800			1	800
	Gonzaga University.....			1	87,200			1	87,200
	Pacific Lutheran College.....	1	6,900					1	6,900
	Saint Martin's College.....					1	1,160	1	1,160
	Seattle Pacific College.....					1	6,410	1	6,410
	Seattle University.....			1	68,800	1	10,990	2	79,790
	State College of Washington.....	10	144,100	2	146,600			12	290,700
	University of Washington.....	19	450,840	3	91,100	1	1,100	23	543,040
	Walla Walla College.....	1	8,000					1	8,000
	Western Washington College of Education.....			1	67,600			1	67,600
	Whitman College.....	1	4,800	1	5,120			2	9,920
	State Total.....	32	614,640	10	467,220	4	19,660	46	1,101,520

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
W. Va.	Bethany College			1	$6,080			1	$6,080
	Concord College			1	9,310			1	9,310
	Marshall College			1	63,800			1	63,800
	National Radio Astronomy Observatory					1	$6,180	1	6,180
	Salem College					1	2,820	1	2,820
	West Virginia University	3	$41,500	1	89,300	2	14,550	6	145,350
	West Virginia Wesleyan College			1	49,000	1	6,330	2	55,330
	State Total	3	41,500	5	217,490	5	29,880	13	288,870
Wis.	American Anthropological Association					1	22,000	1	22,000
	American Phytopathological Society					1	8,500	1	8,500
	Lawrence College	1	13,400			2	20,100	3	33,500
	Marquette University	5	78,940	1	4,850	1	2,650	7	86,440
	Milwaukee School of Engineering			2	8,100			2	8,100
	Northland College			1	8,630			1	8,630
	Ripon College			1	65,300			1	65,300
	Saint Norbert College			1	2,980			1	2,980
	University of Wisconsin	35	3,274,656	4	398,600	5	79,600	44	3,752,856
	Wisconsin State College	1	5,200	1	47,700	1	6,600	3	59,500
	State Total	42	3,372,196	11	536,160	11	139,450	64	4,047,806
Wyo.	Casper College	1	3,000					1	3,000
	University of Wyoming	3	65,900	7	468,600			10	534,500
	State Total	4	68,900	7	468,600			11	537,500

GRANTS AWARDED BY THE NATIONAL SCIENCE FOUNDATION IN SUPPORT OF SCIENCE AND IN SUPPORT OF SCIENTIFIC MANPOWER TO UNIVERSITIES AND OTHER NONPROFIT INSTITUTES DURING FISCAL YEAR 1959—Continued

Other than State	Institution, Individual, or Organization	Support of Science		Support of Scientific Manpower				Total	
				Teachers' Institutes		Other than Institutes			
		No.	Amount	No.	Amount	No.	Amount	No.	Amount
Bermuda	Bermuda Biological Station	2	$10,750					2	$10,750
	Bermuda Total	2	10,750					2	10,750
Canada	McGill University	1	35,700					1	35,700
	Queen's University	1	10,100					1	10,100
	University of British Columbia	2	11,200					2	11,200
	Canada Total	4	57,000					4	57,000
France	Institute Pasteur	1	40,250					1	40,250
	France Total	1	40,250					1	40,250
Israel	Sidney A. Bernhard	1	4,000					1	4,000
	Israel Total	1	4,000					1	4,000
Puerto Rico	Catholic University of Puerto Rico			1	$25,100			1	25,100
	Inter-American University of Puerto Rico			1	20,200	1	$5,500	2	25,700
	University of Puerto Rico	2	18,050	6	160,120	2	17,600	10	195,770
	Puerto Rico Total	2	18,050	8	205,420	3	23,100	13	246,570
Sweden	University of Uppsala			1	9,000			1	9,000
	Sweden Total			1	9,000			1	9,000
Turkey	Robert College	1	5,200					1	5,200
	Turkey Total	1	5,200					1	5,200
	Grant Total	1,819	55,472,189	619	33,385,755	602	15,911,055	3,040	104,768,999

Dollar value of research proposals received and grants awarded by program and fiscal year

PROPOSALS RECEIVED

[In thousands of dollars]

Program	Actual, fiscal year 1957	Actual, fiscal year 1958	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Developmental	$1,669	$2,578	$3,287	$4,100	$4,700
Environmental	2,671	3,776	5,075	6,300	7,300
Genetic	1,864	3,323	4,150	5,200	6,000
Metabolic	0	5,907	6,495	8,100	9,400
Molecular	6,021	6,460	11,506	14,300	16,600
Psychobiology	2,606	3,947	4,196	5,300	6,100
Regulatory	4,961	6,527	7,957	9,900	11,500
Systematic	2,821	4,317	5,136	6,400	7,400
General	4,577	3,368	4,224	5,400	6,000
Total	27,190	40,203	52,026	65,000	75,000

GRANTS AWARDED

Developmental	$385	$604	$1,436	$1,757	$2,000
Environmental	764	953	2,312	2,880	3,300
Genetic	644	711	1,695	2,074	2,400
Metabolic	0	1,311	3,073	3,758	4,400
Molecular	1,753	1,438	3,966	4,857	5,750
Psychobiology	777	968	1,501	1,928	2,100
Regulatory	1,763	1,075	2,491	3,051	3,500
Systematic	697	1,036	2,437	2,977	3,500
General	577	444	894	1,123	1,200
Total	7,360	8,540	19,805	24,405	28,150
Percent of dollar value of proposals awarded grants	27.0	21.2	38.1	37.5	37.5

Another impetus to the increase in applications for research support is a broadened interest in research relating to outer space. While the major responsibility relating to research on problems of space rests with other governmental agencies, the Foundation is responsible for fundamental studies which have no obvious or immediate technological applications. Another aspect of the crucial role played by the environment in influencing biological events is reflected in an increasing interest on the part of biological scientists (stemming to a considerable extent from IGY activities) in biological oceanography. A recent report by the NAS–NRC Committee on Oceanography stresses the increasing role that marine biologists must play in the general field of oceanography—a scientific field which has been very much neglected in the United States. The volume of research applications in this area of biological science has increased sharply in the last 2 years.

One other aspect of the increasing dollar workload in proposals relates to longevity of research grants. Prior to this time, it has not been possible to provide long-term support for many research projects, the average life of a grant being approximately 2.5 years in fiscal year 1959. It is hoped that in fiscal year 1961 an appreciably greater number of 5-year grants will be recommended. In so doing, better continuity of research support will be provided.

The most significant feature of the continuing increase in proposal receipts is the concurrent increase in the number of applications for continued support. Although each proposal from whatever source is considered on its individual merit, applications for continued support represent somewhat special cases in that having gone through rigorous prior screening, they are usually recommended by advisers for full support in contrast to partial support normally given initial requests. This trend, which is increasing each year, plus the fact that the cost of research is increasing, tends to reduce the availability of free funds for the support of investigators requesting National Science Foundation support for the first time. To illustrate the effect increases in renewal applications have had and will probably continue to have on program funds, fiscal years 1958 and 1959 experience can be recounted.

During fiscal year 1958, 25 percent or $10 million of the total applications for support received were renewal requests. Almost 40 percent of total pro-

gram funds were used to provide 35.3 percent of the $10 million requested. During fiscal year 1959, 31 percent or $16.2 million of the total proposal receipts were renewal applications. Almost 50 percent of total program funds were expended to provide 61.9 percent of the amount requested. It is anticipated that this trend will continue and that during fiscal year 1960, 60 percent of total program funds will be granted to support renewal requests and that this percentage will grow to about 72–75 percent in fiscal year 1961. Thus, less than 25 percent of the total dollar value of grants made in fiscal year 1961 will be in support of new requests, which will probably total about $37 million during that year.

Basic research in the biological and medical sciences is aimed in the most general sense at an understanding of living matter, both plant and animal. The research interest currently evident within Foundation programs range from investigations into the structure of living tissue at the submicroscopic level, including studies of how various molecules might have combined to result in the origin of living matter; research on the mechanisms controlling reproduction, growth, and development; research on the nature of the genetic material and how it functions; investigations into the influence of environmental factors as they affect biological systems; research on the functioning of organs and organ systems; studies of the behavior of organisms, both animal and human; and research on the relationships within and between various levels of organisms, both plant and animal.

Organizationally, the Biological and Medical Sciences Division has "programs" covering eight areas: molecular biology, genetic biology, developmental biology, metabolic biology, regulatory biology, environmental biology, psychobiology, and systematic biology. These programs, taken together, encompass the spectrum of basic biological and medical science. As proposals are submitted to the Division they are assigned to the most appropriate program for administrative handling, with complex proposals that cut across several areas being handled as divisional responsibilities. The primary aim of this organization is to insure that all basic biological and medical research problems which are submitted to the Foundation will be given adequate consideration.

Characteristically, support of basic biological and medical science is provided by grants for the support of research (ranging from relatively narrow project-type grants to very broad programmatic grants), grants for the support of symposia and conferences, grants in support of research by advanced graduate students and medical students during the period of thesis work and during free summer periods, and the support of travel to international congresses. Grants for the support of research and collateral activities are generally administered through the use of advisory panels. Although final responsibility for recommending support of a given activity rests with the appropriate program director, he is assisted in arriving at his recommendation by the advice of outstanding biological and medical scientists who comprise the advisory panels. Panels meet regularly three times a year to review research and other types of applications and, when deemed necessary and desirable, panel evaluations are supplemented with additional reviews by ad hoc referees.

Without describing in complete detail the substance of the research support program, fiscal year 1961 will see the continuation of support of studies on physical properties of biological systems, including such areas as photobiology and bioenergetics. Continued support also will be given to genetic studies on all kinds of animals, plants, and microorganisms. In the study of metabolic processes within the cell, grants will support work on all varieties of living organisms, animal, plant, and microbial. Research in the realm of developmental biology will continue to center around the physicochemical basis of cell division, growth, and tissue transformation which are involved in growth and development. In environmental biology, unquestionably there will be expanded interest in research on the gross effects of biological, physiological, and chemical conditions which impinge upon the activities, interrelationships, distribution, welfare, and the physiological systems of individual organisms and populations of organisms. This area of research, of course, will relate to current emphasis being given to problems of the organization and maintenance of life in exotic environments, such as might be expected in outer space. At the level of organ and organ-system function, the Foundation will continue to support research on fundamental physiological processes, as well as on studies of the physiological and neurological mechanisms underlying behavior. Lastly, in a most fundamental area of biological science, the Foundation will continue

to support long-range studies of speciation and the evolution of complex patterns of animal and plant life.

To turn from the general dimensions of the Fundation's projected activities to specific highlights of its current program, the following project descriptions will serve to illustrate some of the exciting work being supported in the biological and medical sciences by the Foundation. Perhaps the most baffling problem in biology is the origin and fundamental nature of life itself. Certainly one of the most exciting accomplishments of 20th century science would be to delineate the conditions which were necessary for the origin and maintenance of life. There are several conflicting scientific views with reference to the conditions required for the origin of the most simple living system. One hypothesis is based on the assumption that the first living organisms were similar in character to the simplest organisms still found on the earth. As a test of such a hypothesis, the major problems are to synthesize the building blocks which are presumed to comprise living material at the most basic level and to further complicate these primitive materials through successive organizational levels to a point where the material is capable of self-duplication.

Working along such lines, Urey and Miller have demonstrated that amino acids can be synthesized by the action of a spark discharge occurring in a mixture of methane, ammonia, water, and hydrogen. These gases are thought to have been essential and plentiful components of the atmosphere of primitive earth. Miller has further demonstrated that amino acids and peptides can be synthesized by ultraviolet light acting on methane gas dissolved in an appropriate aqueous solution. The Foundation is continuing to support the work of Miller at Columbia University in experiments aimed at determining whether various types of phosphates, treated in appropriate ways, may be involved in the synthesis of more complex organic compounds.

The Foundation is also supporting the work of Dr. Sidney Fox at Florida State University, which is directed toward studying the simplest forms of living material. In earlier work, Dr. Fox showed that certain amino acids were present in disproportionately large amounts in simple forms of protein (polypeptides) and in the mixture of free amino acids found in the sap of green plants and in the body fluid of animals. He also demonstrated that these amino acids were "transfer agents" for nitrogen atoms. From this work, it was postulated that an excess of two amino acids, glutamic and aspartic acid must be present for the formation of the simplest of living material. By further work along this line, proteins have been synthesized which show many of the properties of natural protein, especially as regards similar molecular weight solubility and acceptability as substrate by bacteria. The Foundation is continuing to support Dr. Fox in his further investigations of the synthesis of protein and its modification to form more complex biochemical derivatives.

Also at the molecular end of the biological spectrum, one of the most significant scientific endeavors currently being supported by the Foundation is that of Dr. S. E. Luria at the Massachusetts Institute of Technology. Dr. Luria's major research interest is in the molecular aspects of the organization and functioning of viruses, one of the most simple forms of living matter. Dr. Luria is investigating the mechanism whereby the genetic material from viruses enters bacterial cells and is incorporated into the bacterial chromosomes, later to control specific cellular functions through the association of the virus material with the bacterial genes. On the basis of work to date, it is possible to define the time and site of the primary event that gives rise to the new genetic complex and to analyze the cells in which the primary events occur. Thus, both the molecular structure and the function of virus genetic elements may be studied at various stages of their evolution in the recipient bacterial cells. Eventually, Dr. Luria hopes to extend his research to the study of virus infection of mammalian animal cells. If successful, this program of research will result in a more fundamental understanding of the genetic material of cells, as well as of the processes of virus infection and transmission.

Dr. Luria's work illustrates how one moves in basic biological research from studying molecular structure to investigating fundamental biological functions which are linked to molecular structure. This point is also illustrated in certain genetic research supported within the Foundation's grant program. Before discussing such work it might be well to define some basic concepts underlying research in biochemical genetics. Somewhat oversimplified, these assumptions are: (1) That all biochemical processes in living organisms are under genic control; (2) that these complicated biochemical processes may be broken down into a series of simple individual steps; (3) that each step is controlled by a

single gene function, and (4) that mutation of a single gene alters the ability of a cell to carry out a particular primary chemical reaction. In short, the underlying notion is that each gene controls the production, function, and specificity of some chemical product within the functioning organism.

An important program, currently being supported by the Foundation, which is oriented toward solving the problem of how genes act to control the metabolic (biochemical) activities of cells is that of Drs. Charles Yanofsky and Irving Crawford of Stanford University, who have described a genetic system which may lead us very close to an ultimate understanding of the relationship between the fine structure of genes and the biochemistry of the cell. They have mapped a series of changes (mutations) within a particular gene which controls the production of a specific enzyme protein (the enzyme which catalyzes the synthesis of the amino acid, tryptophan) in the bacterium, *Escherichia coli*. Mutation at any point within this gene may cause loss of the enzyme activity of the protein. In some cases, although much of the specific enzyme activity is lost, an altered protein can be detected by immunological techniques; in other cases, no related protein is formed. In either case, it is possible to produce reverse mutations in the gene, so that the enzyme activity and other characteristics of the protein are fully or partially restored. Thus, they now have a large series of proteins, including the original active protein, proteins produced by mutated genes and which are inactive as enzymes, and another series whose activity has been partially or fully restored by a reverse mutation. They are now determining the amino acid sequence in each of these proteins so that they can correlate differences in amino acid sequence both with changes in enzymatic activity and with a map of the mutation sites in the gene. With such a knowledge of the correlation between the fine structure of the gene, the type of enzyme produced and the chemistry of the cell, it may eventually be possible to modify cellular metabolism directly by changing the gene itself or by externally controlling the synthesis of its product.

In the area of metabolic biology the Foundation is supporting a significant project, under the direction of Dr. Bernard Davis at Harvard University, aimed at understanding basic physiological and metabolic processes at the cellular level. Dr. Davis and his coworkers are using an interesting "mutant" technique in their studies. It is possible to secure bacteria (mutants) which cannot form certain essential metabolites from the relatively simple compounds absorbed from the surrounding media because they lack the ability at some stage of the complex multistepped path of synthesis to go ahead to the next step. The addition of the deficient substance or enzyme permits the cell to proceed with the synthesis of the metabolite. Various mutant strains can be developed, each of which stops at a different step; these can be used to map the synthetic pathway step by step. Dr. Davis, by this means, is studying the transport of various substances into cells, particularly in relation to why the cell can absorb certain substances in relatively large quantities while, at the same time, excluding other not-too-dissimilar materials. The transport appears to be effected by means of chemical "carriers" located at the cell wall which are specific for those materials absorbed. However, little is known regarding how these operate, whether they bring about a true chemical change, or whether they merely attach themselves to the material and shuttle it across the cell wall. His group is also mapping the biochemical pathway by which sulfur is converted from the inorganic to the organic form which functions to promote growth. In addition, they are clarifying the various steps by which carbohydrates are used in the cell. These problems are basic to the metabolism of all living organisms, but can be best studied in such microscopic forms of life as bacteria which reproduce so rapidly that huge numbers can be cultured and subjected to varied experimental conditions in a relatively short period of time as compared with large, multicellular plants or animals.

A basic problem in developmental biology is that of growth control and regulation. Growth during normal development is more than an overall increase in size; it involves also an exquisite regulation of the relative growth rates of individual tissues and parts. The end result is a correctly proportioned body with a harmonious balance of different tissue elements. Since growth is basically a matter of protoplasmic synthesis and cell division, the governing mechanisms must operate at these levels. The growth mechanisms and processes not only operate harmoniously to bring about development: they are also held in check when adult dimensions are attained. An escape from the latter restraint is one of the features of the cancer process. The Foundation supports many studies of growth regulation in both plants and animals. Illustrative is the

work of Viktor Hamburger and Rita Levi-Montalcini in the Department of Zoology at Washington University in St. Louis. These investigators have discovered that certain mouse sarcomas contain a diffusible agent which strikingly stimulates the growth of spinal and sympathetic ganglion cells in the developing chick; other cell types are unaffected. A factor with similar effects can be extracted from salivary glands of rodents, and from reptile venom. The venom factor has been identified as a protein and has been shown to stimulate the synthesis of nerve-cell protein. The physiological significance of these growth-stimulating factors is being attacked on a broad spectrum. The outcome cannot yet be predicted, but the potentialities are great.

A highly controversial subject among biologists for more than a quarter of a century has concerned the possibility that certain environmentally induced qualities may be "inherited" temporarily by plants and animals. Lack of adequate environmental control facilities has prevented until recently an accurate quantitative estimation of the validity of this phenomenon in higher plants. Drs. Sterling Emerson and Frits Went of the California Institute of Technology, working under the auspices of the Foundation, have obtained preliminary evidence indicating that both growth habit and growth rate of certain plant strains are quite markedly affected by the temperature conditions that obtained as much as three generations earlier. The polen evidently acts as an agent for the transmission of these effects. Associated with these findings are other data which indicate strongly deleterious but reversible effects on growth when the plants are subjected to constant temperature conditions for several generations. NSF support is enabling these investigators to continue their studies in an effort to determine the magnitude and details of these environmental effects and, possibly, to delineate the genetic or physiological mechanisms by which the plants respond to such influences. The results of the work can have far-reaching implications for our understanding of the basic biology of hereditary processes. Certainly the applied uses of such information would be exceedingly great in the fields of plant and animal breeding and of crop production.

We have been describing problems and projects of interest to basic biological and medical scientists at the molecular, cellular and developmental levels in order to illustrate various research approaches at these levels. There are equally fascinating and challenging problems at the level of integrated organismal functions. For example, an apparently universal characteristic of animal forms is the ability to orient themselves in space and time by means of mechanisms which can most simply be described as "biological clocks." The essential feature of these mechanisms is that they allow orientation of organisms with reference to time and space in much the same manner as manmade systems. Amphipods, for example, possess a "biological clock" which responds to elevation of the sun, from which they get the cues initiating their vertical migrations. There is other evidence which indicates that certain forms have multiple rhythms interacting with each other simultaneously in different frequencies so that "rhythm mixing" results in new cycles. Some of these "biological clocks" are triggered by temperature stimuli, whereas others may be linked to different environmental cues such as light stimulation or moisture stimulation. It is obvious that these most effective integrative orientation systems require the support of information storage and retrieval systems which are related to a time mechanism. It is also clear that a great many cyclic events in the environmental interrelationships of organisms occur and are stored over extended periods of time. In short, timed stimuli apparently can be stored in organisms at primitive levels. However, we are still relatively ignorant about the evolution of such systems within organisms from lower to higher levels and from general modalities to highly discriminating sensory organs within any one organism.

The Foundation is supporting research in several laboratories in the country in the general area just described. For example, Dr. Colin Pittendrigh at Princeton University has one of the outstanding laboratories in this field. His program of research is comparative in nature in that the organisms being investigated include a relatively complete range from mammals to fungi and algae in the plant kingdom. Dr. Pittendrigh's working hypothesis assumes that all organisms are capable of time measurement in that their "clocks" have a common and ancient basic mechanism. This basic element is an oscillatory system with a natural period evolved to match, approximately, the earth's rotation or its annual circling of the sun, and interacting with the revolution of our moon around the earth. As an example, one of the best known biological rhythms is that of the daily periodicity of the onset of running activity in small rodents. An analysis of this periodic system has shown that the hamster "clock"

has an error that does not exceed minutes in 24 hours in its activity pattern. Within limits such patterns of activity may be modified in various organisms by appropriate techniques, but it has also been demonstrated that there are limits beyond which these systems may not be violated without causing great stress and eventual death to the organisms involved.

In considering such problems as that of biological "clocks" it is obvious that they a e of importance in and of themselves. However, an interesting contribution is being made from such fundamental biological research to the development of storage and detrieval systems relating to communication technology and to the advancement of space technology. That various flying, terrestrial, and aquatic animals exhibit abilities to sense direction, to discriminate time periods, and to integrate such cues is directly relevant to the development of new concepts in mechanical and electronic analogs.

In contrast to research aimed at such primitive mechanisms of integration as illustrated by work on "biological clocks," the Foundation is supporting research on what is perhaps the most complex and highly evolved integrative mechanism to be found in living matter, namely, the mammalian central nervous system. What we as individuals know of the world about us and what we experience is largely determined by as yet poorly understood processes occurring within and among the nerve cells within our bodies. Incoming sensory information flows up the peripheral nervous system from several varieties of sense organs into the central nervous system and out again, transmitting "instructions" of various sorts. Although relatively little is understood of this system, the study of the structure and function of neutral tissue has been an area of important research for several years. Among the things which are known of the nervous system is that nervous impulses are in some respects similar to electric impulses. What we have yet to learn essentially concerns an elaboration of this basic dicovery. Research on the nervous system which is being supported by the Foundation is of a wide variety, encompassing studies of the nature of the nerve impulse (Mauro, Rockefeller Institute, New York), the structure and function of nerves and fibers (Wright, University of Florida), the nature of composite nerve impulses (Austin, University of Oregon), and specialized work on specific nerve fibers such as is illustrated in the visual system (McNichol, Johns Hopkins).

Recent advancements in the technology of electrode implanation and recording have permitted research on the role of the nervous system as a whole, in the control of complex behavior, exemplified by psychomotor responses, emotional behavior, and social behavior. For example, the Foundation is supporting the work of Dr. John S. Stamm at the Institute of Living, Hartford, Conn., as well as work in other laboratories, the purpose of which is to study the neurological bases of various behavior patterns, including what occurs in the brain during the learning of simple response patterns. The research techniques involve direct electrical stimulation of cortical areas through electrodes implanted at various points in the cortex, used in conjunction with the establishment of simple behavior responses. From such work it has been demonstrated that specific motor responses may be evoked by direct stimulation of cortical areas. Complex responses such as yawning, sneezing, and licking also have been demonstrated by appropriate direct cerebral excitation. With animal subjects it has further been shown that emotional behavior (aggressiveness) can be elicited and modified by direct stimulation of appropriate brain areas. In short, such studies reveal that many aspects of integrated behavior can be elicited and modified by direct stimulation of the brain. Although the work is largely confined to primate subjects at present, several useful applications may be expected eventually, such as diagnostic assistance in certain forms of brain dysfunctions and perhaps the modification of more complex emotional disturbances.

Parenthetically, in discussing research on neural tissue, particularly on the metabolic aspects of nerve cell behavior, a generally little understood point might be clarified, not relating to the results of research but relating to a sometimes held view that biological scientists do fairly queer things. We have been asked, for example, what possibly could be of interest to biological scientists in the behavior of fireflies. Now, such behavior has its own intrinsic interest, but it also happens that this phenomenon relates to the problem of nerve tissue maintaining its electric function for several hours when oxygen metabolism is inhibited by certain chemical processes, and energy sources other than oxidation must be used for cellular metabolism. In studying this aspect of nerve tissue metabolism, it has been discovered that one of the enzymes in the firefly light-producing reaction is useful as a detector for certain components of the nerve cell's metabolism under anaerobic conditions. Thus, neurobiologists have found both a need and a use for the firefly in their research.

Departing from the laboratory, an area of research in the biological sciences which is of fundamental importance to the whole field is the problem of the systematic relationships between plants and animals. This general area is referred to as "systematic biology" and frequently is seen as being somewhat less glamorous than areas of experimental biology. In systematic biology most research is aimed at studies of groups of organisms for the purpose of identifying the particular group and determining the evolutionary relationship between it and other groups of organisms. The Foundation is supporting one very important large-scale research enterprise in systematics, a biological exploration of the so-called lost world of the Guayana Highland of South America. The importance of this area stems from the fact that it has been geographically isolated for millions of years and has had no biological influence either on or from surrounding areas. A recent expedition, supported by the Foundation under the direction of Dr. Bassett Maguire of the New York Botanical Garden, has discovered numerous types of plantlife which, because of this isolation, have developed forms which are not to be found anywhere else in the world. Another interesting aspect of the findings of this expedition is that no novel animal life was discovered nor any trace of any extinct civilization. This and other similar programs of biological exploration may be expected to yield much new information that will help round out the history of numerous plant and animal lines.

Through the support of conferences and symposia, the Foundation also will contribute to the collateral support of biological and medical research. The annual Cold Spring Harbor Symposium is an excellent example of the kind of meeting supported by grants. Another typical case of conference funding is represented by the regional embryology conference held periodically at various points around the country under the auspices of the American Society of Zoologists. Such conferences make a special effort to encourage graduate student and junior investigator participation, in addition to making provisions for the attendance of one or two distinguished research investigators from distant geographical areas.

Thus, through research support, through the training of graduate students, through the interchange of scientific ideas engendered by the support of conferences and symposia, and through the exchange of visits between U.S. scientists and those abroad, the National Science Foundation is contributing to the scientific enterprise of the United States. In the above examples, both the nature of and various approaches to basic biological and medical science have been pointed out. In so doing, an attempt has been made to differentiate between basic biological and medical science and research directed toward the commonly recognized products of applied biological and medical science which appear in such forms as antibiotics and hybrid corn. It should be remembered that all of these highly glamorizing end products had their beginnings in some relatively obscure laboratory setting.

Dr. WATERMAN. We have similar pages in the mathematical, physical, and egineering sciences, 37 to 44.

MATHEMATICAL, PHYSICAL, AND ENGINEERING SCIENCES

Mr. YATES. Put pages 34 and 35 in the record; and the data relating to those charts appears on pages 36 through 44. Those may go into the record, too. Those are descriptive of the work of the Foundation.

(The pages referred to are as follows:)

MATHEMATICAL, PHYSICAL, AND ENGINEERING SCIENCES, $39,400,000

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Programs totals	$22,985,407	$31,488,842	$39,400,000

The Foundation carries out this program by making grants to universities, colleges, and other institutions for the support of research by scientists whose proposals are considered to be of high quality and significance.

It is expected that about $105 million in research proposals will be received in the mathematical, physical, and engineering sciences program in fiscal year 1961. The expected proposal receipt total in fiscal year 1961 is $20 million, or 23.5 percent above the fiscal year 1960 level. The rate of increase in proposal receipts from fiscal year 1960 to fiscal year 1961 is comparable to the annual rate of growth actually experienced by the Foundation through fiscal year 1959.

In fiscal year 1961 the Foundation plans to support about 37.5 percent of the dollar value of the expected proposal receipt total. A comparison of proposals received, grants made, and the ratio of support planned from fiscal year 1959 through fiscal year 1961 is as follows:

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Value of proposals received	$66,266,631	$85,000,000	$105,000,000
Value of proposals supported	22,985,407	31,488,842	39,400,000
Value of proposals not supported	43,281,224	53,511,158	65,600,000
Percent of dollar value of proposals supported	34.7	37	37.5

The table on the following page compares proposal receipts and grants awarded in each program area for the period from fiscal year 1957 through fiscal year 1961. This table shows the relative constant growth in each of the program areas and the impact of the introduction of the increasingly significant disciplines of atmospheric science and oceanography as separate programs within the Foundation's basic research support effort.

MATHEMATICAL, PHYSICAL, AND ENGINEERING SCIENCES

Dollar value of research proposals received and grants awarded by program and fiscal year

PROPOSALS RECEIVED

[In thousands of dollars]

Program	Actual, fiscal year 1957	Actual, fiscal year 1958	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Astronomy	$996	$3,249	$4,354	$6,500	$8,500
Atmospheric sciences	0	0	[1] 9,793	6,000	7,500
Chemistry	6,667	12,409	10,342	15,000	19,000
Earth sciences	4,215	6,741	8,385	6,500	7,500
Oceanography	0	0	0	[2] 5,000	7,000
Engineering sciences	9,457	10,378	13,449	18,000	22,000
Mathematical sciences	2,333	4,358	8,643	10,500	12,000
Physics	3,923	11,845	11,300	17,500	21,500
General	2,553	0	0	0	0
Total	30,144	48,980	66,266	85,000	105,000

GRANTS AWARDED

Astronomy	$518	$1,033	$1,602	$2,489	$3,200
Atmospheric sciences	0	0	[1] 2,742	2,200	2,700
Chemistry	2,232	2,336	4,333	5,600	7,000
Earth sciences	771	1,229	2,096	2,300	2,900
Oceanography	0	0	0	[2] 1,800	2,700
Engineering sciences	1,356	1,509	4,170	6,600	8,200
Mathematical sciences	933	1,322	2,551	4,000	4,600
Physics	1,380	2,107	5,491	6,500	8,100
General	428	0	0	0	0
Total	7,618	9,536	22,985	31,489	39,400
Percent of dollar value of proposals awarded grants	25.2	19.5	34.7	37.0	37.5

[1] New program in fiscal year 1959; includes both atmospheric sciences and weather modification; weather modification is made a separate program in fiscal year 1960.
[2] Included in earth sciences in prior years.

The continuing increase in total dollar value of proposals received, which is expected to continue through fiscal year 1961, results from a number of factors, which include the general growth in the level of research; a need to support a greater portion of the increased number of significant research proposals of large size now being received by the Foundation; and, a continuing increase in the average size of grants made. These factors are explained in the following paragraphs.

The overall increase in proposal receipts reflects a general growth in national effort and capability in basic research. There is an increase in the number of young scientists capable of performing high quality basic research and in the scientific opportunities open to investigators. Further, there has been a particularly rapid growth of research potential in oceanography and atmospheric sciences, as reflected by an allocation of about 15 percent of planned grant resources to these programs in fiscal year 1961.

An increasing number of proposals of large size—over $200,000—is being received in the mathematical, physical, and engineering sciences; to date, the Foundation has had limited capabilities to support these larger proposals. A summary of the most recent experience for proposals and grants over $200,000 is as follows:

	1958	1959
Proposals:		
Dollar amounts	$9,685,247	$19,368,594
Percentage of dollar value of proposals received	19.8	29.2
Grants:		
Dollar amounts	$1,198,000	$2,013,700
Percentage of dollar value of grants awarded	12.5	8.8

Examples of large grants made in fiscal year 1959 are:

Title	Amount	Location of work
Atmospheric sciences: Research in cloud physics	$383,700	University of Chicago.
Oceanography: Study of deep ocean current systems	290,000	Woods Hole Oceanographic Institution.
Engineering sciences: Interdepartmental research on ionized plasma.	500,000	Massachusetts Institute of Technology.
Physics: Balloon monitoring of cosmic rays and solar phenomena.	350,000	University of Minnesota.
Physics: Research to extend the energy range of electrostatic accelerators.	240,000	University of Wisconsin.

In fiscal year 1961, the Foundation plans to develop increased capacity for award of grants of large size in conformance with the growing size and complexity of the many fields of research today.

There has been a substantial increase in average grant costs since fiscal year 1956 in the mathematical, physical, and engineering sciences. This trend reflects in part the general increase in costs for this period, and particularly the requirement for a greater allowance for specialized research equipment which is increasingly necessary to perform modern research. From an average value of about $21,500 in fiscal year 1956, grants in this program increased to an average level of about $32,000 in fiscal year 1959. During this period the average duration of grants made increased only slightly. It is expected that this experience will continue through fiscal year 1961.

PURPOSE AND DIRECTION OF PROGRAM

The entire program in mathematical, physical, and engineering sciences is an effort to increase our understanding of nature. In spite of the spectacular advances made in science up to this time, it is safe to say that man has made very little headway in his effort to understand the physical world. Although the basic laws determining the forces between atoms are well established, much remains to be learned about their application to complex chemical materials, both those occurring naturally and those made by man. Although we have put nuclear energy to work in our technology, we have not yet reached a full understanding of the forces between nuclear particles. The laws governing the new

elementary particles observed at extremely high energies remain a challenging mystery. In the atmospheric sciences, we are just beginning to understand clouds and precipitation mechanisms, atmospheric dynamics, and the structure of the upper atmosphere. The earth's crust and its oceans present an endless list of problems not yet solved. Radio astronomy and the promise of observations in outer space give us hope that a new era is opening up in man's effort to probe the mysteries of the universe. Even in the more prosaic realm of engineering sciences, where knowledge can be put to work as soon as it is gained, vast areas remain unexplored. For example, the general laws of heat transfer are known, but their application to complex engineering systems presents formidable difficulties. The same situation can be found at the frontiers of metallurgy, chemical engineering, and many other fields vital to our progress in technology.

The course in scientific progress cannot be predicted accurately or planned in detail. Hence, it is always necessary to support research on a very broad front, remembering that great advances sometimes come unexpectedly, at times almost by accident. Increase in knowledge is the immediate goal of research, but experience has proven again and again that scientific knowledge gives man greater control over his physical environment and leads him inevitably to new technological developments. Science not only supplies information needed for specific problems, but much more importantly it opens up new opportunities which cannot be foreseen until the new knowledge is obtained.

From a short-term point of view the number of research scientists is fixed, although increasing their number is a long-range goal of the Foundation. Hence, for fiscal year 1961 the objective of all Federal research support programs must be to make the individual scientist as effective as possible in carrying out his creative work. This can be done by providing him with adequate equipment, adequate assistance, and sufficient time to do his job.

Mathematics is the basic language of the physical sciences. It is not usually recognized that many problems which we face in science and technology, including some at the forefront of our knowledge, are really mathematical problems. Such disciplines as mechanics, aerodynamics, hydrodynamics, electromagnetics, thermodynamics, quantum mechanics, relativity, and many others are as much mathematics as they are physics or engineering. Among problems of particular current interest many can be considered from a purely mathematical viewpoint; e.g. calculation of satellite orbits, determination of the behavior of automatic control systems, prediction of shock waves resulting from explosions, development of hydromagnetic theory as a basis for energy production from hydrogen fusion. Furthermore, the problems which we face in these areas require the most advanced techniques available to modern mathematics. The continued development of mathematical theory is therefore essential for growth and progress in science and technology generally.

The great task of astronomy is to understand the universe by observing the radiations coming to us from stars and from material in interstellar space. Four major developments are now adding or soon will add greatly to the power of the astronomers' observations. These are radio astronomy, observations from high altitude balloons, space vehicle observations, and image intensification by electronic means. Astronomy in the United States will be greatly strengthened as the two national observatories, the National Radio Astronomy Observatory at Green Bank, W. Va., and the Kitt Peak National Observatory near Tucson, Ariz., come into operation. In addition to its direct support of these observatories, the Foundation will support astronomers from all over the country in their use of these installations. High altitude astronomical observations from balloons have been so successful using a 12-inch telescope that a program has been initiated to develop a remotely controlled 36-inch telescope for stellar and planetary astronomy. Space vehicles offer a unique opportunity for making observations free of atmospheric absorptions, and the Foundation is planning to support research by astronomers which looks toward utilization of such vehicles.

Research in physics has emphasized the fundamental laws governing matter and energy in their relation to time and space. In recent years primary emphasis has been on nuclear and elementary particle physics and on the physics of systems composed of many atoms, such as solids. Probably the most challenging area of physics today is the study of events in the energy range above 1 billion volts. The National Science Foundation plans to support university physicists working in this field, including many who will utilize high energy particle accelerators. Observations of cosmic rays provide a natural laboratory for studying events at energies much higher than those obtainable in the labora-

tory and present the physicist with a new mystery, that of the origin of cosmic rays themselves. The problems of many-atom systems range from superconductivity and other poorly understood phenomena occurring near absolute zero to the study of magnetic and electrical properties of solids including semiconductors. The new field of plasma physics is an effort to understand how gases consisting of a mixture of electrons and atoms which have been stripped of their electrons behave in electromagnetic fields. This area is fundamental to astrophysical problems and possibly will provide a basis for nuclear fusion technology and new propulsion systems.

In chemistry, much emphasis is placed on understanding the reaction mechanisms by which molecules are synthesized or interact with each other. This effort has been stimulated by increasing capability of quantum mechanical theory to predict and interpret molecular events. Of particular importance are reactions occurring under extreme conditions of temperature or pressure, or where intermediary materials, catalysts, play a decisive role in the reaction. Such research is of critical relevance to the synthesis of new useful materials and to the improvement of industrial chemical processes and to problems of combustion and corrosion. In the field of organic chemistry, which deals with the structure and synthesis of carbon compounds, much of the effort relates to problems in molecular biology and forms a basis for understanding chemical processes in living systems. At the same time, advances are constantly being made in areas which promise improved materials such as polymers and fuels. The field of inorganic chemistry is considered to be underdeveloped in this country, and efforts will be made to strengthen our position in this field. Vast areas remain to be explored in the chemistry of boron, phosphorous, and many other potentially important classes of materials.

The atmospheric sciences program, established in fiscal year 1959, supports research on the atmosphere and its phenomena from the surface of the earth to outer space. Directed toward gaining a better understanding of the atmospheric environment, composition, mechanisms, and interrelationships, the program will stress research on the physics of the upper atmosphere, energy exchange processes, cloud physics and water substances, general atmospheric circulation and dynamics, and solarterrestrial relationships. It is planned to increase the fiscal year 1961 budget for the program over the fiscal year 1960 level in recognition of the expected growth of significant research in the field. The special program on weather modification is discussed separately in this document.

The earth sciences program is concerned with the physics, chemistry, and history of the solid and liquid parts of the earth. It thus embraces projects that range from field geologic studies to theoretical and experimental chemistry, from studies of earthquake waves and magnetism to the history and development of living organisms. Of all the various subdisciplines included in earth sciences, oceanography and seismology seem particularly in need of increased effort at this time and will receive additional emphasis in fiscal year 1961. The recent acceptance by scientists and nonscientists alike of the report by the Committee on Oceanography of the National Academy of Sciences is good evidence of the importance and lack of development in that field. The recommendation of this report to expand basic research in all aspects of marine science is in good agreement with the desires and plans of the National Science Foundation. In fiscal year 1960 a part of the budget of the earth sciences program was specifically set aside for oceanography, and this amount will be increased in fiscal year 1961.

Seismology, the study of earthquake waves, has recently assumed great importance in international affairs because of its potential use in monitoring underground nuclear explosions. A great deal more basic understanding is needed about the nature of earth vibrations and the structure and composition of the earth. Basic research projects to be supported will include high-pressure, high-temperature laboratory experiments and the development of techniques for using high-speed computers as well as extensive field studies using newer and more sensitive instruments.

Engineering sciences research seeks knowledge that is directly needed in the design of new and improved technological systems. Programs in this field must be judged not only on their scientific promise, but on their potential value to technology. Just as there are frontiers in pure science, so there are frontiers in technology which require new research information as well as the creative synthesis of engineering development. All these frontiers are characterized by our having reached the extreme limits of existing techniques and materials. Challenging problems confront the engineer in many fields such as: structure,

propulsion, and navigation of space vehicles; high-speed data processing systems; improved reliability of electronic equipment; communication systems; control and automation of industrial production; application of nuclear energy to transportation and electrical power production; more efficient use and effective conservation of natural resources. Basic research in engineering sciences does not solve these problems directly but rather provides the essential information and methods with which existing problems can be solved and new opportunities recognized. Engineering science must be understood as being more than an intensive study of certain problems in physics, chemistry, and mathematics selected because of their applicability to engineering design. It includes the scientific study of the complex machines and systems which have been developed for technological use, with the objective of understanding how such systems can be designed for maximum efficiency and reliability at minimum cost. The National Science Foundation program in engineering sciences is very broad and attempts to undergird and balance the national effort in this field, which is also heavily supported by Federal agencies having specific mission-related technological objectives.

As an indication of the types of research being supported by the Foundation, and as an indication of results obtained, examples of current significant projects follow:

A cooperative effort between the National Institute of Oceanography of England and the Woods Hole Oceanographic Institute has resulted in the confirmation of the existence of an ocean current underlying the Gulf Stream and flowing generally in the opposite direction. This current had been predicted on theoretical grounds, but its existence was unproved until the recent project. The research will be continued with Foundation support in an attempt to determine the mean drift of these deep midocean currents in the presence of large irregular fluctuations.

It is well established that developments in controlled nuclear fission are directly dependent on further basic knowledge of convection and boiling heat transfer mechanism. Heat transfer in chemically reacting fluids is encountered in chemical-process reactors and in such specialized fields as jet propulsion where missile aerodynamic heating is accompanied by dissociation of air. Dr. D. M. Mason of Stanford, working on heat transfer rates in chemically reacting fluids, has measured boiling heat transfer rates in reacting system of nitrous-oxide. Due primarily to the high thermal conductivity of the system, heat transfer coefficients with values 11-fold higher than those in air were observed. An extension of this work is the current study of a chemical system with known reaction kinetics behavior and physicokinetics which can be more readily separated from the role played by heat, mass, and momentum transfer processes.

At the other end of the temperature scale, at very low temperatures some metals display abnormally high electric conductivity, or superconductivity, which is the vanishing of resistance near absolute zero. Encouraged by recent theories concerning the superconductive properties of metals, experimental physicists began to look for the presence of "energy gaps" in the superconducting region. Evidence for the "energy gap" has slowly built up in the last 2 years; most significant perhaps were the experiments of Doctors P. L. Richards and M. Tinkham of the University of California at Berkeley, in which they studied the absorption of infrared rays in thin films of superconducting metals. They not only discovered existence of the predicted "energy gap," but were able to verify that the energy at which it occurred was in essential agreement with the theoretical value. At Barnard College, Dr. H. A. Boorse measured the specific heat of metals in the superconducting state. His data also gave substantiating evidence to the presence of a gap in the energies of the superconducting electrons. These two experiments, taken together wth the theory, comprise a major advance in our understanding of superconductivity.

Martin Schwarzschild of Princeton University, with the assistance of a current National Science Foundation grant and the continued interest and support of the Office of Naval Research, made a series of observations from a remote balloon-borne, 12-inch telescope during the summer of 1959. A sequence of high-resolution photographs of the surface of the sun was made which indicated not only the shape of the polygonal convection cells, but also the manner in which these cells form and dissolve. Several small sunspots were photographed in much greater detail than ever previously attained. The filamentary structure of the penumbra was revealed and shown to change with time much more slowly than the granules. These flights were the first in which the pointing and focusing of the telescope was remotely controlled from the ground and in which

the field of view of the telescope was continuously monitored on the ground by television. It is expected that many of the techniques developed in connection with this project will find application in satellite and moon-based instruments.

Work in weather modification in fiscal year 1961 will stress theoretical and analytical studies of the fundamental processes involved in the development of clouds and the precipitation mechanisms. This includes cloud physics, cloud chemistry, and cloud electrification.

GRANTS AWARDED

Mr. THOMAS. Did he give us a little preview on the number and types, et cetera, of the institutions? How many altogether do you have?

Dr. WATERMAN. Last year, fiscal year 1959, 1,685 basic research grants.

Mr. THOMAS. What do they average apiece, about $20,000 or $25,000?

Dr. WATERMAN. About $25,000 plus.

Mr. THOMAS. How long have these grants been going on and how many of them are continuing? Are they on a 2- or 3-year basis?

Dr. WATERMAN. The average is a little under 2½ years for the fiscal year 1959.

Mr. THOMAS. How many are terminated at the end of 2½ years? Are they all extended?

Dr. WATERMAN. There is a spread. That is the average. On renewals we commonly renew in the two divisions roughly 75 percent, a little under that perhaps. We put renewal applications in competition with the new proposals that come in.

Mr. JONAS. I had a question on that subject, Mr Chairman.

Mr. THOMAS. Go ahead.

INCREASE IN AVERAGE GRANT

Mr. JONAS. I notice this average grant is increased to $30,500 in fiscal year 1960 over an average of $17,200 in 1958. What accounts for the increase in the average?

Dr. WATERMAN. Increased costs, increased salaries, and increased length of contract or grant.

Dr. GROSS. Mainly on the length of contract, is it not?

That is the one that extends the time of the grant.

Dr. WATERMAN. Yes, but not entirely. The average duration of grants has only increased from 2 years in 1958 to 2.26 years in 1959.

Mr. JONAS. I didn't think there would be a substantial increase in cost between 1958 and 1960. Actually, I thought costs had been rather stable during that period.

Dr. WATERMAN. Universities' salaries have had a lag there. They have been slow in increasing theirs so that now comes into the picture. They are still increasing their salaries in universities as they can. That has been a rather slow process.

Mr. JONAS. That is pretty nearly a 100-percent increase in the average grant.

Dr. WATERMAN. Yes. Equipment costs more because the general costs of equipment are higher and because specialized equipment is increasingly expensive.

Mr. JONAS. This does not include equipment, does it?

Dr. WATERMAN. Yes. A grant typically is divided between costs of scientists and assistants working on it, and the cost of equipment and material which they need and sometimes costly instruments that they need to buy. All those are in the picture.

Mr. JONAS. That is all.

WEATHER MODIFICATION

Mr. THOMAS. Weather modification.

Put pages 43 and 44 in the record.

(The pages referred to follow:)

WEATHER MODIFICATION, $2,000,000

Obligations

	Actual, fiscal year 1959 [1]	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Program total	0	$2,000,000	$2,000,000

[1] Included in basic research in fiscal year 1959.

Public Law 85-510 of the 85th Congress established the responsibility of the National Science Foundation to take the lead in supporting and stimulating research aimed at achieving effective weather modification.

Work in weather modification in fiscal year 1961 will stress theoretical and analytical studies of the fundamental processes involved in the development of clouds and the precipitation mechanisms. This includes cloud physics, cloud chemistry, and cloud electrification.

Major emphasis will also be given laboratory and field experimental studies. Laboratory efforts will include the following: studies of condensation and freezing nuclei, analysis of cloud droplet formation and growth, and studies of electrical effects. Field work in fiscal year 1961 will include the gathering of data on naturally forming clouds and rain-producing clouds, and the carrying out of well-designed cloud-seeding experiments. Measurements of liquid water content, drop-size distribution, temperature, electrical charge, freezing particles, cloud circulation, etc., will be made.

Research and development work on instruments and measurement techniques will also be carried on in fiscal year 1961 based on laboratory and field needs for specific instrumentation.

To date, work on weather modification has caused much controversy, both among the general public and in scientific circles, centered around the question of whether experiments designed to modify the weather have actually led to cloud formation, additional rainfall, and other related results.

Much of the controversy stems from a very real lack of fundamental knowledge of the basic physical processes of cloud formation, tornadoes, rain, fog, and other related natural phenomena and from our inability in the past to carry through well-designed, long-term field experimentation. While much of the evidence to date is inconclusive, there is a reasonable basis for predicting that some measure of long-range success in effective weather modification is possible. The potential scientific and economic gains of continued work is clearly worth the effort.

The basic National Science Foundation approach to the problem is intensive work in the various fields required to develop detailed understanding of the physical processes involved, coupled with a program of field experimentation to test out and develop further knowledge. Some direct experimentation in cloud and weather modification will be included, with the proportion of such effort increasing as further knowledge is gained. The development and application of effective systems of weather modification must be regarded as a long-range program.

An example of weather modification work now being carried on under an NSF grant, is the investigation of physics of clouds and of cloud modification,

by University of Arizona scientists. They have tentatively concluded that under the conditions of the test rainfall was increased on days in which seeding was carried out, and that many more lightning strokes were observed on seeded days.

The weather modification program will be carried out by means of grants and contracts with colleges and universities, other private and public institutions, as well as by appropriate arrangements with other Government agencies having interests in the applications of research in this field.

Mr. THOMAS. Dr. Wexler and Dr. Reichelderfer ask for $2 million for weather modification?

Work in weather modification in fiscal year 1961 will stress theoretical and analytical studies of the fundamental processes involved in the development of clouds and the precipitation mechanisms. This includes cloud physics, cloud chemistry, and cloud electrification.

Who is doing this work?

Dr. WATERMAN. A number of establishments. The Weather Bureau gets quite a bit of it. We also provide this money by grants to universities and research institutions. Again, this is a matter of making a selection of the best scientific work that is proposed.

Mr. THOMAS. How much money was spent for research in weather?

Dr. WATERMAN. Overall this program includes $2 million.

Mr. THOMAS. You have to give a little to Dr. Revelle in addition to this?

Dr. WATERMAN. Yes, sir. That is under oceanography.

Mr. THOMAS. That is part of the weather if you listen to Dr. Revelle.

Mr. JONAS. You have not improved it any yet either, have you?

Dr. WATERMAN. To date, in fiscal year 1960, we have made $570,400 in grants.

Mr. THOMAS. Where are you going to spend this money, in how many institutions?

Dr. WATERMAN. We spend this in universities where this is their specialty—and those are generally the leading institutions that deal in meteorology.

Mr. THOMAS. How much did you have for this purpose last year?

Dr. WATERMAN. I think it is the same amount, $2 million, Mr. Chairman.

Mr. THOMAS. You did not have any in 1959. What part of this $2 million for 1960 has been allocated or obligated?

Dr. WATERMAN. $570,000.

Mr. JONAS. I think you will find this was included in basic research prior to 1960. 1960 is the first time you have put it in as a separate program?

Dr. WATERMAN. Yes. That is when we got the statutory authority.

You understand, of course, that our authority here is largely because it has been proven pretty thoroughly that to do anything with weather modification one has just got to understand the rain-forming, snow-forming process better. This puts it back in basic research, so that is our aim in the program. However, our support of meteorology and, support of work in the atmospheric sciences goes far beyond the weather modification item. We have already obligated $1,141,000 in fiscal year 1959 for that purpose in the broad field of the atmospheric sciences. We just earmarked the weather modification, you see, in line with our statutory responsibility. Then if you add the earth sciences to this picture, since they are closely associated with the at-

mospheric, that provides another quarter of a million, which we have already obligated in this general field.

ANTARCTIC RESEARCH PROGRAM

Mr. THOMAS. Antarctic research program. Put pages 45 and 46 in the record.

(The pages referred to follow:)

ANTARCTIC RESEARCH PROGRAM, $5,500,000

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Program totals	$2,305,903	[1] $7,248,097	$5,500,000

[1] Estimated obligations in fiscal year 1960 include that portion of grants and contracts made with other Government agencies from prior years appropriations which were not obligated by the receiving agencies as of June 30, 1959, in accordance with the sec. 1311 of Public Law 663 concept of obligations. These amounts were reestablished as obligations by the Foundation on July 1, 1959 (*2,228,097).

Funds requested for fiscal year 1961 will provide continuation of scientific research in the Antarctic at the fiscal year 1960 level and in addition, $1.5 million for conversion of a surplus Military Sea Transport Service ice-working ship to a scientific research vessel. This will provide a capability for year round offshore operations which will permit important oceanographic Antarctic research for the first time. In addition, research will also be conducted on board ship in other areas such as meteorology, cosmic ray, etc.

Scientific research is carried out in the Antarctic through support of a field group of Antarctic scientists comprising the U.S. Antarctic research program or USARP. This group of scientists consists of a winter season team which will be on duty in the Antarctic from October 1961 to March 1963, and a summer team of scientists in the Antarctic from October 1961 to March 1962.

Inland traverses carried out by this group of scientists have proved invaluable to the efforts of all who seek to solve the scientific mysteries of the Antarctic. These traverses take place during the summer months of October through February and involve five to seven men each. During the past 2 years traverse teams of the United States have covered 7,500 miles of inland ice with detailed observations every 30 miles and elevation, gravity, and magnetic observations every 4 miles.

The Antarctic continental scientific stations and traverse routes of the 14 nations participating in Antarctic research are shown on the map on the following page.[1] Not shown are stations located on islands beyond the coastal area but considered as part of the complex of polar stations. Certain planned future traverses are also shown; however, information on these plans by foreign nations is not complete. The following table indicates the stations operated by each nation with the area location.

Table of stations by nations

	Antarctic area	Sub-Antarctic islands		Antarctic area	Sub-Antarctic islands
Argentina	[1] 7		New Zealand	[1] 1	
Australia	[1] 2	1	Norway	1	
Belgium	1		Poland	1	
Chile	4		Union of South Africa		3
France	1	1	United Kingdom	7	1
Italy		1	United States	3	
Japan	1		U.S.S.R.	4	

[1] Plus 1 with United States.

[1] Not printed.

Mr. THOMAS. Give us a little explanation on this Antarctic research program.

You had $2.3 million in 1959; $7.2 million in 1960 and you are requesting $5.5 million for 1961.

These amounts were established as obligations by the Foundation in 1959 with other Government agencies. Who is spending this money for you?

Dr. WATERMAN. This is being spent by grants which are made to other Federal agencies, such as the U.S. Weather Bureau, the National Bureau of Standards, Coast and Geodetic Survey, Geological Survey, and also to universities where they enter into such matters.

Mr. THOMAS. The U.S. Antarctic program has who mixed up in it? The Navy and Weather Bureau had a part in it, as well as the IGY. You wound up with the IGY. Why doesn't the Navy spend their own money? They supply logistics for you, do they not?

Dr. WATERMAN. They spend their own money and are completely responsible for the logistic costs.

Mr. THOMAS. Do you have two camps there or one?

Dr. WATERMAN. We have four all told; the main base and three separate scientific stations.

Mr. THOMAS. Give us a breakdown of the cost of $5,500,000. Has the Navy withdrawn its support? Are you paying for all of it?

Dr. WATERMAN. The Navy is paying completely for the operating costs.

We are only paying for the scientific program, which means the instruments, salaries of scientists, et cetera.

Mr. THOMAS. How many people are involved? You have had the instruments for 3 or 4 years. Why this $5.5 million.

Dr. WATERMAN. Dr. Joyce?

Dr. JOYCE. Mr. Chairman, there are about 88 people involved in this present operation this year. The number will go up to about 101 scientists next year and also about that number for the program we are requesting. This includes both winter and summer teams. The majority of these people are summer scientists. They go down in October and stay through the Antarctic summer, take part in geological exploration.

Mr. THOMAS. How do you arrive at this figure of $5.5 million when the Navy is furnishing the logistics? They transport you there, feed you, and bring you back, do they not?

Dr. WATERMAN. The standard program in Antarctica costs $4 million and the Foundation is carrying responsibility for the Government on the scientific program. That amount, $4 million is the same as last year.

The additional $1.5 million is for the renovation and outfitting of a vessel which can be used in the Antarctic for scientific research, largely oceanography, so the base figure remains the same as it was last year.

The additional $1.5 million is to outfit this vessel.

Mr. THOMAS. How much have you obligated or expended of your 1960 funds for this project? You had about $7,200,000.

Dr. JOYCE. We only had $4 million, Mr. Chairman.

Mr. THOMAS. But you had transferred funds to you.

Dr. WATERMAN. These were funds left over from the previous year that were not used; is that right, Mr. Luton?

Mr. LUTON. Yes.

AMOUNTS OBLIGATED

Mr. THOMAS. What part of your funds were obligated as of January 1?

Dr. JOYCE. About 75 percent of the funds available for each year's program are obligated by the end of the year. The balance will be retained for reduction, observation, and analysis.

Mr. THOMAS. Can't you give us a more exact figure than that?

Does anybody have it?

Dr. WATERMAN. We can give you an accurate figure for the record?

Mr. SCHOEN. We can put an accurate figure in the record. Of this $7.2 million, $2½ million approximately, is for funds that were obligated last year. In accordance with section 1311, this amount had to be deobligated at the end of the fiscal year, and then on July 1 they are reobligated, so that $2½ million is really a bookkeeping transaction, required by section 1311 of the Anti-Deficiency Act.

Of the balance, of which there is about $4½ million approximately, I think over $3 million will be obligated by June 30.

Mr. THOMAS. At the end of fiscal year 1960 how much of that $7.2 million will be unobligated and unused?

Mr. SCHOEN. About $1 million, I would say, sir.

Mr. THOMAS. Is that a guess figure?

Mr. SCHOEN. That is a fairly good guess; yes, sir. Most of that is money that is required for data reduction and the completion of the research when these teams return, during fiscal year 1961.

ESTIMATED COSTS

Mr. THOMAS. $2.3 million will be used for salaries, $1.3 million will be for scientific equipment. The Department of Defense will continue to provide all logistics support. How much are they spending on the program? Do you remember?

Put page 49 in the record. It gives us a table on this.

(The page referred to follows:)

Estimated costs of Antarctic scientific program by field group and type of expense

	USARP–1960 fiscal year 1959		USARP–1961 fiscal year 1960		USARP–1962 fiscal year 1961	
	Number of personnel	Dollar amount	Number of personnel	Dollar amount	Number of personnel	Dollar amount
Field group:						
Salaries and related costs:						
Winter team:						
U.S. stations	24	$710,000	30	$930,000	30	$930,000
Cooperative stations	13	400,000	14	430,000	14	430,000
Summer team, U.S. stations	51	820,000	57	910,000	57	910,000
Subtotal	88	1,960,000	101	2,270,000	101	2,270,000
Equipment:						
Field equipment and supplies		520,000		520,000		410,000
Station equipment and supplies		1,142,000		1,000,000		870,000
Subtotal		1,662,000		1,520,000		1,280,000
Total field group expense		3,622,000		3,790,000		3,550,000
Activities within continental United States:						
Reduction and data analysis and equipment development		285,000		150,000		400,000
Oceangoing research vessel		0		0		1,500,000
Advisory committee		93,000		60,000		50,000
Subtotal		378,000		210,000		1,950,000
Program total		4,000,000		1,000,000		5,500,000

Dr. WATERMAN. Something like $10 million or $12 million the Navy has set aside for this.

Mr. THOMAS. Are the British and Russians increasing their activities there?

Dr. WATERMAN. The Russians have been. The British are holding it about as it was, I believe.

Dr. JOYCE. That is correct.

Dr. WATERMAN. As you know, there now is a very fine treaty among the nations for work in the Antarctic, which has been a real achievement by the United States.

The work will be completely scientific in character. There will be no military operations, and there will be free visits from one section to the other to find out what is going on.

DISTRIBUTION OF COSTS

Mr. THOMAS. Put page 52 in the record.
(The page referred to follows:)

U.S. ANTARCTIC RESEARCH PROGRAM

Distribution of cost, by program and field groups

Program	USARP, 1960 (fiscal year 1959)	USARP, 1961 (fiscal year 1960)	USARP, 1961 (fiscal year 1962)
A. Life sciences	$250,000	$330,000	$330,000
B. Earth sciences:			
Geodesy and cartography	220,000	200,000	200,000
Geology	150,000	270,000	270,000
Geomagnetism	82,000	80,000	80,000
Glaciology	800,000	700,000	700,000
Gravity	20,000	15,000	15,000
Seismology	235,000	200,000	200,000
Subtotal	1,507,000	1,465,000	1,465,000
C. Oceanography: Onshore studies	190,000	265,000	75,000
D. Atmospheric sciences:			
Aurora and airglow	190,000	175,000	175,000
Cosmic rays	70,000	35,000	35,000
Ionospheric physics	200,000	220,000	220,000
Meteorology	1,150,000	1,200,000	1,000,000
Subtotal	1,610,000	1,630,000	1,430,000
E. Scientific support activities:			
Related scientific support	350,000	250,000	350,000
Advisory committee	93,000	60,000	50,000
Subtotal	443,000	310,000	400,000
F. Stateside research and data analysis centers	0	0	200,000
G. Mobile research facilities:			
Mobile land station (design and development)	0	0	100,000
Oceangoing research vessel (ship conversion)	0	0	1,500,000
Subtotal	0	0	1,600,000
Total	4,000,000	4,000,000	5,500,000

Mr. THOMAS. This is a breakdown. I do not know how much this means.

BASIC RESEARCH FACILITIES AND GRANTS CONTRACTS

Mr. THOMAS. Put page 70 in the record.
(The page referred to follows:)

BASIC RESEARCH FACILITIES GRANTS AND CONTRACTS, $29,550,000

SUMMARY

The following comparative table shows the approximate distribution of total funds requested for the various research facilities projects and categories based on current estimates and programing. Actual utilization of funds appropriated under this activity title will be based on the most current judgments of advisory panels and the National Science Board as appropriate in order to assure effective application of dollar resources in terms of the total needs of science.

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
Development of graduate research laboratories	0	$2,000,000	$15,000,000	+$13,000,000
Biological and medical sciences	$3,269,800	2,000,000	3,000,000	+1,000,000
Mathematical, physical, and engineering sciences:				
University computing facilities	1,500,000	1,500,000	2,000,000	+500,000
University nuclear equipment	2,000,000	2,000,000	0	−2,000,000
Oceanographic research vessel	0	3,000,000	2,750,000	−250,000
Atmospheric sciences facilities	0	500,000	1,500,000	+1,000,000
Maintenance and operation of National research facilities:				
National radio astronomy observatory	4,405,000	900,000	3,000,000	+2,100,000
Kitt Peak National observatory	4,349,925	900,000	2,000,000	+1,100,000
Hawaiian Geophysical Institute	0	0	300,000	+300,000
Subtotal, mathematical, physical, and engineering facilities	12,254,925	8,800,000	11,550,000	+2,750,000
Total basic research facilities	15,524,725	12,800,000	29,550,000	+16,750,000

As indicated by the table above, the fiscal year 1961 funding request for basic research facilities contains a number of significant changes in the distribution of funds among major areas of program activity. The fiscal year 1961 budget estimate of $29,550,000 for grants and contracts for basic research facilities is an increase of $16,750,000 or 131 percent over the fiscal year 1960 level.

Mr. THOMAS. "Support of science, basic research facilities and grants contracts."

We have gone into this with some detail, particularly the big increase of $13 million out of your $29.5 million for research laboratories.

You have no funds this year for nuclear.

Dr. WATERMAN. That is right.

Mr. THOMAS. We have gone into Dr. Revelle's ship. Did he agree that he could build that boat this year for $2 million?

Dr. WATERMAN. That is our understanding—that it could be done for $2.75 million. We badly need one vessel in the Atlantic and one in the Pacific.

Mr. THOMAS. I am glad you agree with us. I doubt if the doctor made that agreement though.

NATIONAL RADIO ASTRONOMY OBSERVATORY

Mr. THOMAS. Tell us about the Radio Astronomy Observatory. How is it doing?

Dr. WATERMAN. Very well. This is coming along nicely. They already have done a very fine piece of research.

Mr. THOMAS. Who is operating that for you?

Dr. WATERMAN. This is operated by Associated Universities, Inc., with Director Otto Struve, a very distinguished radio astronomer.

Mr. THOMAS. Is our distinguished friend from New York, Dr. Berkner, still looking over his shoulder at us?

Dr. WATERMAN. He is president of the Associated Universities.

Even with the equipment they have at present at the Observatory at Green Bank, the radio astronomers have succeeded in mapping the center of our galaxy for the first time. They have radio signals that show the structure of the galaxy in which the earth exists, for

the very first time. You cannot reach that by ordinary telescopes. Our galaxy is identified by the Milky Way, and ordinary optical telescopes cannot see through the Milky Way, but the radio telescopes can, so the astronomers all over the world are quite impressed by this achievement.

Dr. GROSS. It is a breakthrough?

Dr. WATERMAN. Yes.

Mr. THOMAS. Is this maintenance cost $3 million?

Dr. WATERMAN. Not entirely. We can give you that breakdown.

Mr. LUTON. On the capital budget, we have $1,775,000, and on operations and maintenance we have $1,225,000.

OCEANOGRAPHIC RESEARCH VESSEL

Mr. THOMAS. Let us take a look at pages 101 and 102. Put those pages in the record.

(The pages referred to follow:)

OCEANOGRAPHIC RESEARCH VESSEL, $2,750,000

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Program total	0	$3,000,000	$2,750,000

Funds requested in fiscal year 1961 for this program will be used to construct a second modern 175-foot oceanographic vessel. Funds were appropriated for the construction of the first vessel in fiscal year 1960.

Based on current cost analyses, costs anticipated by fiscal years are:

	Estimate, fiscal year 1960	Estimate, fiscal year 1961
DESIGN AND CONSTRUCTION OF 175-FOOT RESEARCH VESSEL		
Design and engineering costs	$190,000	$30,000
Preparation of detailed working drawings	150,000	60,000
Material: Hull, propulsion machinery, electric plant, auxiliary systems, communications and controls, and ship outfit and equipment	1,275,000	1,275,000
Direct labor	560,000	560,000
Contingency (at 5 percent) and miscellaneous	200,000	200,000
Shipyard overhead, profit, and insurance	625,000	625,000
Program total	3,000,000	2,750,000

A modern oceanographic research vessel must have the qualities of long-cruising range, quietness of operation, seaworthiness, ability to handle heavy equipment, stability, adequate laboratory space, and maneuverability at low speeds. The construction of a 175-foot vessel in fiscal year 1961 will permit incorporation of all these qualities and permit effective oceanographic research under a wide range of operating conditions. In addition, a recently completed detailed study of the relative costs and merits of all classes of oceanographic research vessels has indicated the economic merits of this class of vessel in terms of scientific return per dollar expended.

For fiscal year 1960, $2 million was appropriated to build a 140-foot research vessel of the cutter class. On the basis of information available at the time of the fiscal year 1960 budget presentation, it was felt that a 140-foot vessel would fill an extremely useful research function within total fiscal year 1960 funds available to the Foundation. However, studies completed since that time, as referred to above, have emphasized that, while a 140-foot vessel will be needed,

the first priority is for vessels of the 175-foot class in order to permit American oceanographers to undertake a full range of modern oceanographic research in all latitudes in all seasons of the year. This need is made more acute by the necessity of finding a replacement for the *Atlantis*, currently one of the Nation's foremost research vessels, which must be retired in the very near future. Thus, the Foundation has felt it necessary to provide approximately $1 million from total funds available in fiscal year 1960 to build the 175-foot vessel in order to meet this very pressing current need of American science.

The estimated cost of construction of the 175-foot vessels planned for both fiscal year 1960 and fiscal year 1961 are based on the hull, machinery, and outfitting costs of the ships, exclusive of auxiliary scientific equipment. The construction cost of the fiscal year 1961 vessel is expected to be somewhat less than the fiscal year 1960 vessel since the same basic plans and working drawings will be used for both vessels.

With the vessel planned in fiscal year 1961, as with the fiscal year 1960 vessel, it is expected that a grant will be made to a university or oceanographic research institution to permit the grantee to design, contract for, and supervise construction. And, as in the case of the fiscal year 1960 vessel, it is expected that the vessel supported with fiscal year 1961 funds will be a replacement for an existing research ship, rather than an additional vessel, because of the great length of service of nearly all active U.S. oceanographic ships.

It is expected that the operating and maintenance cost of this vessel, as with the fiscal year 1960 vessel, will be provided from a variety of sources, including private, State, and Federal organizations.

Mr. THOMAS. Dr. Revelle agreed to that reduction in his absence. Does that give him three or four ships? I was thinking we gave you one or two ships last year out of this budget.

Dr. REID. One.

Mr. THOMAS. How many more did you have? Did you have four old ones?

Dr. REID. That is right.

Mr. THOMAS. What shape are they in now?

Dr. REID. The youngest is nearly 20 years old.

Mr. THOMAS. It will be old enough to vote in 1 more year. When are you going to get them in the water?

Dr. REID. The new ones we are building?

Mr. THOMAS. Yes.

Dr. REID. I am sorry I can't say. The newest is still in process of design at the moment. It will be laid down, I hope, within a few months.

Mr. THOMAS. What will be the construction time required? Can you build it in 12 or 13 months?

Dr. REID. I would hope so. I cannot be specific.

Mr. THOMAS. Who has the contract to build them?

Dr. REID. I do not know.

Dr. ROBERTSON. The first ship the Science Foundation has 1960 money for is being built for Woods Hole Oceanographic Institution. They had the preliminary design. They are now making a detailed design. They have not let the contract yet, I believe.

Mr. THOMAS. Woods Hole had not let the contract. I guess it will go to a yard in Quincy. That is nearby.

Dr. ROBERTSON. That is a possibility.

Mr. THOMAS. What control are you gentlemen keeping of the money?

Dr. ROBERTSON. We have provided in advance for periodic approvals of the successive steps in the construction.

Mr. THOMAS. When they finish construction, will you have maintenance and operation money for it?

Dr. ROBERTSON. We anticipate that the operation of the ship will be paid for out of oceanographic research funds, which will come both from the Navy and the Science Foundation.

Mr. THOMAS. We build a ship and then maintain it.

Mr. BOLAND. Have they maintained the *Atlantis* in this way?

Dr. ROBERTSON. I think maintenance funds for the *Atlantis* comes primarily through Navy research funds, and some Scientific Foundation funds as well.

Mr. JONAS. Who owns these ships? Who will be in control of them?

Mr. THOMAS. The Research Institution, Woods Hole.

Dr. ROBERTSON. Woods Hole Oceanographic Institution will own the ship. We made the grant to them.

Mr. JONAS. They will own it, operate it, and be responsible for its assignments?

Dr. ROBERTSON. That is correct.

NATIONAL RADIO ASTRONOMY OBSERVATORY

Mr. THOMAS. Let us take a look at the laboratory. We can call that Astronomy Laboratory ours, can't we?

Dr. WATERMAN. We own it but do not operate it.

Mr. THOMAS. It is still ours. Put 109 and 110 in the record.

(The pages referred to follow:)

NATIONAL RADIO ASTRONOMY OBSERVATORY, $3,000,000

A summary of funds authorized to date and funds requested for fiscal year 1961 for the National Radio Astronomy Observatory is as follows:

	Fiscal year 1957 through fiscal year 1959	Estimate, fiscal year 1960	Total through fiscal year 1960	Estimate, fiscal year 1961
Program total	$9,480,000	$900,000	$10,380,000	$3,000,000

The distribution of funds authorized and requested, by use or purpose, follows:

	Total availability		Estimate, fiscal year 1961
	Fiscal year 1957 through fiscal year 1959	Estimate, fiscal year 1960	
Site development and protection	$963,000	$70,000	$210,000
Buildings and housing	1,127,000	0	170,000
Research equipment:			
85 foot and 140-foot radio telescope construction	6,050,000	0	0
Telescope improvement program	0	0	400,000
Fixed zenith 300-foot telescope	0	0	300,000
Radiofrequency components and electronic equipment	470,000	160,000	550,000
Subtotal	6,520,000	160,000	1,250,000
Other observatory equipment	239,000	50,000	145,000
Maintenance and operation costs	631,000	620,000	1,225,000
Total	9,480,000	900,000	3,000,000

A total of $3 million is requested for the National Radio Astronomy Observatory, or an increase of $2,100,000 over the fiscal year 1960 level of $900,000.

As the Observatory approaches full-scale operations, the financial impact in fiscal year 1961 is demonstrated not only in increases in staff and equipment in the direct astronomy and electronics research programs, but also in the necessary supporting service functions such as maintenance personnel, increased costs of electricity and fuel oil, and necessary additional housing for staff and visitors.

Further, in fiscal year 1961, the Observatory will be in a position to pursue programs for the improvement of the basic research telescope so as to insure maximum flexibility and research capability of these instruments. These progams involve the procurement of components, the development of receivers, and the making of direct improvements to the basic research instruments.

Finally, funds are requested to permit addition of an important new basic research telescope and to provide for a public demonstration building for directing and controlling onsite visitors.

A summary explanation of the budget estimate, by the major Observatory categories, shown on the table, follows:

Site development and protection, $210,000

	Total availability		Estimate, fiscal year 1961
	Fiscal year 1957 through fiscal year 1959	Estimate, fiscal year 1960	
Site acquisition and protection	$600,000	0	$75,000
Onsite roads and utilities	277,000	0	25,000
Electric power and communications	86,000	70,000	110,000
Total	963,000	70,000	210,000

The Green Bank, W. Va., site was selected as nearly ideal for radio astronomy research because of the low level of manmade radio interference from home and commercial electrical equipment, radios, automobiles, etc.; $75,000 is requested in fiscal year 1961 to provide for a program of protection of the site against a rise in the interference level which would decrease the effectiveness of the radio telescopes. Of the total for this category, $50,000 is needed for improving equipment which will identify and eliminate radio interference. The balance, $25,000, is planned for acquisition of or easements on critical sites which would otherwise become potential sources of radio interference, and for the construction of visitors parking areas.

An amount of $25,000 is required to provide for a road to the 300-foot fixed zenith telescope planned for fiscal year 1961.

The sum of $110,000 is required to provide underground electrical service to auxiliary sites, and necessary additional voltage regulation equipment and switching stations in order to provide for the planned on-site plant load.

Mr. THOMAS. You are through with the construction costs. You have $1½ million in here for facilities. Are you through with the facilities and your construction costs for this $3 million?

Mr. LUTON. There will still be some more construction costs.

Mr. THOMAS. How much more?

Off the record.

(Discussion off the record.)

Dr. WATERMAN. Everything depends in this field as in others on what progress is made in research. If a new instrument or new technique is developed for observation, then they will naturally come to us to see if this cannot be added to what they have; it is a little hard to forecast that kind of thing.

Mr. THOMAS. How many people does he have for $1¼ million?

Dr. WATERMAN. Ninety-one.

Mr. THOMAS. He really went up there.

Dr. WATERMAN. These are planned for 1961.

Mr. LUTON. The staff in 1960 is 58. They estimate 91 in 1961.

Mr. THOMAS. How many top scientists do you have there? You built them a dormitory. I thought there would be visitors and you would have only a staff of six or eight people. The others would go in and do researching and go home.

Dr. WATERMAN. Quite a number of technicians and maintenance people are required.

Mr. THOMAS. How many maintenance people are there?

Mr. LUTON. About 43 people come under business administration, maintenance, and categories of that type.

Mr. THOMAS. You ought to have more maintenance.

Mr. LUTON. The other people in the 91 would be scientists, for instance, the Director and the astronomy department.

Mr. THOMAS. How many scientists live on the ground?

Mr. LUTON. Right now we do not have much place for them to live.

Mr. THOMAS. What became of that nice dormitory and those messhall facilities and private quarters? We built a nice little hotel there.

Mr. LUTON. We have 16 rooms there in the residence hall, a cafeteria, and 4 apartments.

Mr. THOMAS. Sixteen rooms and how many apartments?

Mr. LUTON. Four. These will be taken up primarily by the visiting scientists and then we have there on the site some remodeled farmhouses.

Mr. THOMAS. How many of those are there?

Mr. LUTON. There are about seven of those which have been remodeled and are available for occupancy. One of those is used more or less as a quarters for the men who come there without families.

Mr. THOMAS. How long do they stay there? These are maintenance, operation people or scientists?

Mr. LUTON. These are scientists mainly.

Mr. THOMAS. Off the record.

(Discussion off the record.)

Mr. LUTON. I think we should make this clear on that particular point, and that is that most——

Mr. THOMAS. We will take you at your word and we will make it clear in this year's budget.

Mr. LUTON. All right. Many of the maintenance people are hired from the region and do not live on the site. This is also true of the people in the business office.

Mr. THOMAS. You have $170,000.

Dr. WATERMAN. This is a capital instrument which does require maintenance for its operation and the same is true of auxiliary equipment such as the computing devices.

Mr. THOMAS. This has been in operation about 6 or 8 months, has it not?

Dr. WATERMAN. On the smaller telescope.

Mr. LUTON. The 85-inch telescope has been in operation for about a year.

Mr. THOMAS. How about the big one?

Mr. LUTON. The big one is still in process of construction.

KITT PEAK NATIONAL OBSERVATORY

Mr. THOMAS. Let us take a look at Kitt Peak. What are we doing in Kitt Peak? You ask for $2 million. Put pages 118, 119, and 120 in the record.

(The pages referred to follow:)

KITT PEAK NATIONAL OBSERVATORY, $2 MILLION

Funds are requested in fiscal year 1961 to provide for the operation and maintenance of the Kitt Peak National Observatory, together with necessary equipment and facility additions. The observatory is being constructed at Kitt Peak, Ariz.; offices and laboratories are located in Tucson, about 40 miles away. A summary of funds approved to date and requested for fiscal year 1961 for the observatory is as follows:

	Fiscal years 1958–59	Fiscal year 1960	Total through fiscal year 1960	Estimate, fiscal year 1961
Program total	$7,545,000	$900,000	$8,445,000	$2,000,000

The distribution of funds by major category and by fiscal year follows:

	Current availability		Estimate for fiscal year 1961
	Fiscal year 1958–59	Estimate, fiscal year 1960	
Site development	$756,883	$28,000	$108,000
Construction of observatory facilities:			
City laboratory and offices	659,439	49,000	247,000
Facilities at Kitt Peak	336,183	55,000	206,000
Subtotal	995,622	104,000	453,000
Research telescopes:			
16-inch telescope	2,000	0	0
36-inch telescope	233,028	0	0
80-inch telescope	1,559,290	195,200	56,000
Solar telescope	3,335,000	0	185,000
Advanced optical telescope program	0	0	175,000
Subtotal	5,129,318	195,200	416,000
Operations and maintenance	663,177	572,800	1,023,000
Total	7,545,000	900,000	2,000,000

A total of $2 million is requested for the Kitt Peak National Observatory in fiscal year 1961, an increase of $1,100,000 over the fiscal year 1960 level. The principal factor contributing to the increase in fiscal year 1961 over fiscal year 1960 is the initiation of an advanced optical research telescope design program. This program aims at a major advance in optical astronomy by developing a large, remotely operated telescope for use in an earth satellite. To carry out this program in fiscal year 1961, personnel, supplies, and materials will be required in addition to continuing program requirements of the observatory; more city laboratory space will be required; and specialized facilities and telescopes will be required at the Kitt Peak site.

A second factor contributing to the increase in fiscal year 1961 over fiscal year 1960 results from normal growth to nearly a full-scale research program for presently scheduled facilities. The impact of such a program results not only in an increased number of direct research personnel for training and operation, but also increased auxiliary personnel, supplies, and related expenses.

As a third factor related to the start of nearly full-scale operations, it will be necessary to provide certain buildings and site improvements not needed until the presently scheduled plant is almost completed. For example, roads and parking lots will require surfacing, and area fencing must be completed. In addition, a public reception building will be needed to handle the substantial numbers of persons who will wish to visit the site after the major instruments are completed.

A description of program plans represented by the amounts requested in each of the major observatory categories follows:

SITE DEVELOPMENT, $108,000

	Current availability		Estimate for fiscal year 1961
	Fiscal year 1958–59	Estimate, fiscal year 1960	
Surveys and area development	$59,318	0	$25,000
On-site roads	30,000	$7,000	30,000
Water system	234,000	0	46,000
Telephone and power	171,925	21,000	7,000
Land procurement	231,640	0	0
Total	756,883	28,000	108,000

Surveys and area development.—Funds available through fiscal year 1959 were used for geological and topological surveys, clearing the site, temporary buildings, etc. With essential completion of construction by fiscal year 1961, an extensive fencing program will be necessary: around the observatory grounds at the summit ($6,000); around the water-collecting basins and utility areas ($6,000); line fencing as specified in the lease with the Papago Indians ($5,000); and safety walls and fencing for hazardous areas near the observatory buildings ($8,000).

On-site roads.—Surfacing of the on-site road and paths connecting the various installations and additional parking areas will be required at a unit cost of $3 per square yard. Funds were previously provided for surfacing of the parking areas around the stellar telescope buildings and the basic support facilities. A requirement will exist in fiscal year 1961 to complete surfacing of the main on-site road system and parking areas. The job will include 7,400 square yards of roadways, 2,600 square yards of parking areas and pedestrian paths.

Water system.—While current planning indicates that the collection of rainwater in catchment basins appears the best system, $5,000 is planned for use in fiscal year 1961 to explore and develop alternate water sources in order to supplement the present system. An amount of $16,000 will be required for water and sewer distribution system extensions for new buildings in fiscal year 1961; or about 900 lineal feet, at $17.40 per foot. Lastly, $25,000 will be required to bring water and sewerage services to the public reception center.

Telephone and power.—Approximately $7,000 will be required for about 900 lineal feet of system extensions, at $7.90 per foot.

Construction of Observatory facilities, $453,000

	Current availability		Estimate, fiscal year 1961
	Fiscal years 1958–59	Estimate, fiscal year 1960	
City facilities:			
City office and laboratory	$582,439	0	$200,000
Service building and parking areas, etc.	0	$49,000	0
Optical test tunnel	77,000	0	0
18-foot vacuum sphere	0	0	47,000
Subtotal	659,439	49,000	247,000
Mountain facilities:			
Residences	30,000	55,000	30,000
Office and laboratory	90,000	0	0
Cafeteria and apartments	79,000	0	0
Dormitory	55,000	0	0
Warehouse and service	65,000	0	25,000
Solar office-laboratory	0	0	35,000
Public reception building	0	0	88,000
Architect-engineer services	17,183	0	28,000
Subtotal	336,183	55,000	206,000
Facilities, total	995,622	104,000	453,000

Mr. THOMAS. You are through with this now? You started off with $7,500,000. You had $900,000 last year. I think you got a supplemental. You have $2 million. Operation and maintenance is about half of it.

What is that maintenance and operation figure going to be a year? How many people do you have, et cetera?

Dr. WATERMAN. We estimate $1,023,000 for operation and maintenance, I believe.

Mr. THOMAS. How many people do you have at Kitts Peak?

Dr. WATERMAN. Forty-seven in this year.

Mr. THOMAS. When will you be through with your capital money? You have $2 million in there for this year and half of it is for maintenance; $1,023,000 is for operation and maintenance. What will it cost to maintain it a year? How many people will you have and how much larger will it get?

Dr. WATERMAN. The 16-inch telescope is completed, the 36-inch is completed, and the 80-inch is to be completed. We need $56,000 estimated for 1961. The solar telescope will require another $185,000 and then a new project, advanced optical telescope program, calls for $175,000.

Mr. THOMAS. What will it cost you, and when will it be completed?

Dr. WATERMAN. The 80-inch telescope, Mr. Luton——

Mr. LUTON. The 80-inch optical telescope should be completed in the fourth quarter of fiscal year 1961. It should be completed by June 1961.

Mr. THOMAS. Will you call for an overrun in that or is your money going to be sufficient?

Mr. LUTON. So far it appears they have sufficient funds for the Optical Observatory.

Mr. THOMAS. When you get it completed, what will your maintenance cost be on an annual basis?

You have $1,023,000 in here this year.

Mr. LUTON. I would say approximately between a million and a million and a half dollars per year.

SURVEYS AND REPORTS

Mr. YATES. Mr. Reporter, let us go to page 131 and put that in the record.

(The page referred to follows:)

SURVEYS AND REPORTS, $370,000

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
Program total	$230,254	$367,235	$370,000	+$2,765

This program provides for surveys and special studies of the Nation's resources for scientific research and development, including measures of current magnitude, categories of research, field of activity, and impact upon industrial development and the general welfare. It also serves as a medium for evaluating the effect of Federal programs in science and technology upon non-Federal research and development. The data obtained provide a basis for the formulation of Federal science policy recommendations, as well as furnish a basis for the administration, operation, and the formulation of policy decisions within the National Science Foundation.

Because of the broad objectives and areas of coverage in the program of the Office of Special Studies, a large part of the work is carried out through contractual agreements with competent private and public agencies. Within the Foundation, the small professional staff of the Office is responsible for program planning and analysis, and for supervision and guidance of the contract projects.

The amount requested for fiscal year 1961 will provide for the continuation of the survey series currently underway and for special studies which are explained later. Estimated allocations of the amount are as follows:

STATISTICAL SURVEYS

$90,000 to the Bureau of the Census to complete the 1959 cycle and begin the 1960 cycle of data compilation in connection with the statistical survey of the costs of research and development performed by American industry.

$60,000 to the Office of Education for data compilation as part of a summary survey for the 1958–59 school year and a detailed survey for the 1959–60 school year of research and development performed by the Nation's colleges and universities. These surveys determine the volume of research and development supported by school funds and by outside fund sources, including the manpower engaged and related topics.

Mr. YATES. Doctor, do you want to tell us why this item is necessary?

Dr. WATERMAN. That is a systematic program in the Foundation. There is practically no change in the budget. It makes the statistical surveys of the research and development costs of American industry, the universities and colleges and the Federal Government itself. It also goes into the matter of scientific personnel, engineering personnel, and manpower. The schedule is arranged now so we can get systematic reports of these and publish these to all who are interested, and in this way we are able to establish trends.

Dr. Perlman, who is in charge of this office, has people engaged in determining an index which can be useful in the further planning of this.

There are special studies also, such as: effects of research and development upon the growth and stabilization of the various industries and the economy in general; the analysis of the factors that determine the level of research and development expenditures within private industry; the analysis of the factors affecting the spread of industrial innovations resulting from research and development activities in private industry; impact of Federal research matters, managed by educational institutions, on the faculty staffing, teaching requirements, and organizational structure of the universities.

Mr. YATES. Does the Department of Commerce do any of this?

Dr. WATERMAN. They make studies on national resources, particularly economic resources and the activities of industry. Ours, of course, is concentrated on science and technology and covers all sectors—the Government, universities, and industry.

DISSEMINATION OF SCIENTIFIC INFORMATION

Mr. YATES. The next item is dissemination of scientific information, and we shall insert page 139 in the record at this point.

(The page referred to follows:)

DISSEMINATION OF SCIENTIFIC INFORMATION, $7,335,000

SUMMARY

A comparison of budget estimates by fiscal years for major activities within the dissemination of scientific information program follows: The first table, by dollar amounts; the second, by percentages of total funds.

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Foreign science information	$1,337,737	$1,968,527	$2,290,000
Research, data, and information services	313,411	363,004	740,000
Support of scientific publications	1,083,176	1,425,000	2,280,000
Research on scientific information problems	781,675	900,000	1,190,000
International scientific information exchanges	331,528	735,000	835,000
Program totals	3,847,527	5,391,531	7,335,000
	In percent		
Foreign science information	34.8	36.5	31.2
Research, data, and information services	8.1	6.7	10.1
Support of scientific publications	28.2	26.5	31.1
Research on scientific information problems	20.3	16.7	16.2
International scientific information exchanges	8.6	13.6	11.4
Program totals	100.0	100.0	100.0

The fiscal year 1961 request for $7,335,000 is about 36 percent above the fiscal year 1960 level of $5,391,531. The increase reflects, overall, both the growth of requirements to be met by Foundation support and the Foundation's effort to exercise the role of national leadership in the dissemination of scientific information assigned by congressional and Executive directives.

Mr. YATES. $7,335,000 is requested for this activity for the next fiscal year. This has moved up since 1959 when the National Science

Foundation had $3,847,527. There was $5,391,531 allocated for this activity last year, and now there is a further increase of another $2 million.

How many organizations are engaged in the gathering and dissemination of information of this type? I know that the State Department is doing it and the Army and the Navy are doing it. The Department of Commerce is engaged in it.

Dr. WATERMAN. This is all encompassed under this program. We see that each one is carrying out its share without overlap. Dr. Adkinson can speak to this in detail.

Dr. ADKINSON. The question you asked was, how many agencies in the Government are working in the field of scientific and technical information. There are 17 represented on the Interdepartmental Committee which have major roles in this field. There are other agencies that have some role in the field of scientific and technical information.

The thing that I would like to explain is, these agencies are collecting and organizing information for their particular programs and we collect no information in our program. We are working with the agencies to effect cooperation and coordination. We are not transferring, starting this coming year, any money to other agencies for their scientific information activities.

Mr. THOMAS. How many people do you have in this program?

Dr. ADKINSON. At the present time I believe 56.

Mr. THOMAS. What do the green sheets look like? How many supergrades?

Dr. WATERMAN. I think only one top excepted grade, Dr. Adkinson himself.

Mr. THOMAS. You do not do any translating or any evaluating.

Dr. ADKINSON. We do evaluate.

Dr. WATERMAN. We support translations by grants.

Mr. THOMAS. I am talking about the 56 people that he has.

Mr. LUTON. There are six excepted grades.

Mr. THOMAS. They do no translating. You have seven programs that you support. It looks to me like this program ought to be cut half in two.

Dr. ADKINSON. We have the problem, sir, of developing cooperative programs within Government, which means that we must have people who know and understand the information business in the scientific and technical field. A large share of our fund is used to work with the scientific societies outside who are hard pressed to meet the demand.

Mr. THOMAS. What are you spending for your administrative costs and salary costs and other objects? Break it down.

Dr. ADKINSON. The number of people on my staff is 56 and the total cost is $468,000 for salaries.

Mr. THOMAS. You have a budget here practically of $8 million?

Dr. ADKINSON. Right.

Mr. THOMAS. You are spending $612,000 to give away $7 million. That is a little high, is it not?

Dr. ADKINSON. That is a reasonable question if that were all we had to do—give away the $7.3 million.

Mr. THOMAS. Do not use that word, Doctor; you allocate.

Dr. ADKINSON. Allocate. The real problem we have is working with a large number of scientific bodies and with technical information services within industry.

Mr. THOMAS. An insurance company would allow 5 percent for administrative costs for this same operation, and you are spending about 8 percent.

Dr. ADKINSON. About 8 percent, and about 7 percent, if the foreign currency program is included.

Dr. GROSS. I think this is more of an operating arm of the Foundation. There is no area where there are specialists of this type that are really performing an operational function. Theoretically, the Foundation is not supposed to operate, but here we are in a position where we have to send people who have the competence and can do this coordinating which seems to many of us to be a very, very important problem.

The growth of scientific information is a tremendous sweep as these years have gone on. It is very uneconomical for the Government, industry, or the universities not to know what has been done.

Mr. THOMAS. It costs you $40 or $50 a page to translate some of this?

Dr. ADKINSON. The average cost to translate and publish is about $25 a page.

Dr. GROSS. I want to emphasize the fact that industry puts a tremendous amount of their funds, as they should, into things like chemical abstracts. That has been supported very heavily, not by Government, but by industry. This is in recognition of the fact that if you do not use what is in the printed literature and do it over again in the laboratory, the cost is wasteful. The volume of this is one of the great problems of the day. It is in all areas, but in science it is greater. We have to organize it so it is more generally available to the scientists and not lost.

Mr. THOMAS. We appreciate the value of it. We have gone into it with you and the other gentlemen here year after year. We know the value of it. Can you get about the same results for a little less money than you are spending in this field? The administrative costs are far out of line.

Dr. GROSS. I think if one would regard this just as administrative costs you would be correct.

Mr. THOMAS. If this came up in your own university you would ask a lot of questions.

Dr. GROSS. I think that there is an operational element in here that I would like to stress. That is the point that I would like to make. It is peculiar to this office of the Foundation.

Dr. WATERMAN. We have a statutory responsibility here to take a leading position, not only with Government, but with the universities and industry. This means keeping in touch with scientific societies and what they are publishing and what they are doing, and keeping in touch with industry and their publications, and all of the Federal agencies and what they are doing in scientific information. It also means the translation of articles abroad, especially Russian, and making arrangements to be sure these articles are translated completely when desired and that selected translations are made of important articles.

The same is true of books and monographs. Then there are whole areas of abstracts in the field of science. We have to find out who is doing this work and see that they are effectively being carried on.

Mr. THOMAS. You are handling literally hundreds of instruments. The lawyers call them instruments. You scientists call them abstracts. You are going to translate some. There are going to be hundreds that go to the filing cabinets. Maybe sometime some scientist will have the idea that he may want it and perhaps it will be there. If you ever have occasion to use 10 percent of them that would be a high figure.

Dr. GROSS. The trouble is you never know which 10 percent.

Mr. THOMAS. That is the hazard that you run.

Dr. WATERMAN. This is a field which people who have given it thought over the years feel has been very badly neglected. That is why we were given this responsibility. Aside from that there is the whole problem of when you have identified published materials you have to put them in a library and then the question comes how can you store them where they can be identified? When you have done that, how, and in what form, do you bring them to a scientist-engineer who wants to consult them for his research? So a great deal of research has to go into that technique. Also I think you will recall quite a lot of progress is being made in the mechanical translation of foreign languages. This sounds as though it would be an impossible thing to do, but it is turning out not to be so. We have had some very interesting results. All of these things add to the components in the budget, and since we have taken the leadership here we feel that we cannot afford to take any chances. We have all of these responsibilities and they are extremely important, and require highly competent staffs.

FOREIGN SCIENCE INFORMATION

Mr. YATES. We shall insert page 145 in the record, which shows the foreign science information budget.

(The page referred to follows:)

FOREIGN SCIENCE INFORMATION, $2,290,000

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Translation activities, Russian language:			
Translation of scientific journals	$923,382	$1,041,665	$1,200,000
Translation of books and monographs	63,487	56,862	100,000
Translation of selected articles	37,802	75,000	125,000
Russian-English reference aids	130,659	200,000	190,000
Subtotal	1,155,330	1,373,527	1,615,000
Translation activities, other languages	0	170,000	275,000
Exchange and acquisition of foreign scientific publications	19,160	125,000	125,000
Translation clearinghouses	49,124	30,000	50,000
Information on foreign science	114,123	270,000	225,000
Total	1,337,737	1,968,527	2,290,000

Research carried on in other countries is increasing in volume and significance and thus is of growing importance to American scientists and engineers. Yet much of this information is not directly available because it is published in languages which few American scientists read—Russian, Chinese, Japanese, and

Eastern European langauges. In addition, many foreign language journals are not readily available in American scientific libraries.

The National Science Foundation has established this program to improve the communication of the results of foreign research to American scientists.

RESEARCH, DATA, AND INFORMATION SERVICES

Mr. YATES. Page 149 shows the "Research, data, and information services" budget, which page we shall insert into the record.

(The page referred to follows:)

RESEARCH, DATA, AND INFORMATION SERVICES, $740,000

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Support of announcement and availability services	$50,311	$93,004	$90,000
Support of data, reference and information services	263,100	200,000	560,000
Support of special projects	0	70,000	90,000
Program total	313,411	363,004	740,000

A large percentage of the significant unclassified scientific and technical information resulting from the research of Government, industrial, educational, and other private organizations is not made available through the conventional journal- and book-publication channels. Even though such information may eventually become published, there are extensive timelags, varying from months to years, between the time research is completed, the time the results are submitted for publication, and the time the information actually appears in a scientific journal or book.

The effectiveness with which this large important body of scientific and technical information can be exploited by a U.S. research scientist or engineer in his work is directly dependent upon the extent to which such pertinent information is made readily available to him, and the efficiency with which he can obtain specific needed information in a form which he can easily use.

This program has two major objectives: (1) to provide for systematic optimum public announcement and dissemination of all significant unclassified scientific and technological information which is not published promptly in scientific journals and books, and to encourage its flow into conventional scientific publication channels; and (2) to help make scientific and technical information and data more easily accessible to the Nation's scientific and technological community by means of a well-coordinated system of conventional and specialized reference, data, and information service centers

SUPPORT OF SCIENTIFIC PUBLICATIONS

Mr. YATES. Page 153 shows the support of scientific publications. What form does support of scientific publications take? This is almost doubling?

Dr. ADKINSON. I will explain our support program.

A large number of journals of original research, and monographs on original research are published by organizations that pay for them and run them—largely the scientific societies. They are hard-pressed to the point they cannot publish all the material they should.

When you realize that our scientific research and publication effort is expanding at the rate of doubling every 8½ to 10 years and that it is the individual scientists who are running these societies, they are hardpressed.

Mr. THOMAS. He asked you a question. Give us a list of them here.

Dr. ADKINSON. Here is a listing of the subareas and the number of grants for last year.

Mr. YATES. What about the journals themselves, the names of them?

Dr. ADKINSON. I can get that for you. I do not have it.

Mr. THOMAS. Do you have any there you can read into the record now?

Mr. YATES. Do you remember the names of any of the journals?

Dr. ADKINSON. Yes. I can name some. We have supported such things as Forest Science, Geoscience Abstracts, Meteorological Abstracts——

Mr. THOMAS. How much did you give to Forest Science?

Dr. ADKINSON. A small amount to get them out of trouble, and that is the end. We do not support these on a continuing basis.

Mr. THOMAS. What was the small amount?

Dr. ADKINSON. Around $10,000 or $11,000.

Mr. YATES. What if they run on the rocks again, do you give them another grant?

Dr. ADKINSON. What we try to do is to give grants to do two things: (1) work on the backlog, and the other is to make studies and organize their programs, get their things in order so that they can carry themselves. This is our practice. Ordinarily, our grant is for 1, 2, or 3 years with the understanding that at the end of that time they will be in a position to carry it.

Mr. THOMAS. Would not the Laboratory up in Wisconsin help? There is a Forest Products Laboratory in Wisconsin. Does the Department of Agriculture make any contribution?

Dr. ADKINSON. They did not, as far as we know, except to buy subscriptions. A lot of them feel that is all that they need contribute. Applied Mechanics Review is another.

Mr. THOMAS. When you add all your costs you are right at $10 million rather than $5.5 million, are you not?

Mr. YATES. Will you put a list of the publications in the record?

Dr. ADKINSON. Yes.

(The information requested follows:)

National Science Foundation grants in support of publications (fiscal year 1959)

Title	Institution	Amount	Date
Anthropology: World Bibliography of Fossil Vertebrates and Paleolithic Anthropology (bibliography).	University of California	$25,050	February 1959.
Archeology: Radiocarbon samples and dates (data compilation).	Peabody Foundation for Archeology.	500	May 1959.
Astronomy:			
Bibliography of Extraterrestrial Radio Noise (abstracting journal).	Cornell University	9,200	July 1958.
Bibliography of Astronomy 1881-98, U.S. portion (bibliography).	American Astronomical Society.	8,100	August 1958.
Visual observations of variable stars (data compilation).	American Association of Variable Star Observers.	16,000	December 1958.
Stars and Stellar Systems (compendium)	University of Chicago	8,800	January 1959.
Biology (general): Biological Abstracts (abstracting journal).	Biological Abstracts, Inc.	150,000	Do.
Botany:			
Annotated Bibliography of Reviews in Plant Pathology.	American Phytopathological Society.	8,000	July 1958.
Index of Scientific Names of Algae	University of Illinois	16,000	Do.
Bibliography of the Flowering Plants of Mexico.	University of Pennsylvania	10,500	August 1958.
Index Muscorum (catalog of scientific names of mosses).	International Association for Plant Taxonomy.	11,000	October 1958.
The Characeae (monograph)	University of Rhode Island.	2,300	June 1959.

National Science Foundation grants in support of publications (Fiscal year 1959)—Continued

Title	Institution	Amount	Date
Crystallography: Critical Compilation of Crystal Data (data compilation).	American Crystallographic Association.	$11,500	December 1958.
Engineering:			
Solar Energy (primary journal)	Association for Applied Solar Energy.	43,500	January 1959.
Spray Literature Abstracts (compilation of abstracts).	American Society of Mechanical Engineers.	5,000	March 1959.
Applied Mechanics Reviews (abstracting journal).	American Society of Mechanical Engineers.	10,000	May 1959.
Genetics: Genetics (primary journal)	Genetics, Inc.	35,000	January 1959.
Geology: Geoscience Abstracts (abstracting journal).	American Geological Institute.	60,285	December 1958.
Geophysics:			
Atmospheric Chemistry of Chlorine and Sulfur Compounds (monograph).	American Geophysical Union	3,550	October 1958.
Transactions of the American Geophysical Union, and Journal of Geophysical Research (2 primary journals).	American Geophysical Union.	146,000	December 1958.
Mathematics:			
Mathematical Reviews (abstracting journal)	American Mathematical Society.	55,000	November 1958.
Annals of Mathematical Statistics (primary journal).	Institute of Mathematical Statistics.	18,000	December 1958.
Handbook of Mathematical Tables (data compilation).	National Bureau of Standards.	40,000	February 1959.
Operations research: Bibliography on Operations Research (annotated bibliography).	Case Institute of Technology.	5,000	Do.
Physics:			
Radiocarbon Date Lists (data compilation)	American Journal of Science	2,950	October 1958.
Journal of Mathematical Physics (primary journal).	American Institute of Physics.	64,800	December 1958.
Critical Reviews in Physics (critical reviews).	do	29,325	Do.
High Energy Physics Newsletter (primary journal).	National Research Council	7,000	Do.
Science (general):			
Bibliography of U.S. Abstracting and Indexing Services (annotated bibliography).	Library of Congress	10,000	November 1958.
Arctic Bibliography (abstracting annual)	Arctic Institute of North America.	25,000	December 1958.
Union List of Periodicals Covered by 12 Major Abstracting and Indexing Services.	National Federation of Science Abstracting and Indexing Services.	13,500	June 1959.
Social sciences:			
Scientific Papers of Franz Boas (primary publication).	Northwestern University	12,300	May 1959.
Sociological Abstracts (abstracting journal)	Brooklyn College	5,200	June 1959.
Economic Atlas of the Soviet Union (compendium).	University of Michigan	9,500	Do.
International Journal of Abstracts: Statistical Theory and Method (abstracting journal).	International Statistical Institute.	16,200	October 1958.
Zoology:			
Directory of Specialists in the Taxonomy of Animals.	Society of Systematic Zoology.	6,400	Do.
Butterflies of the American Tropics: the Genus *Anaea* (monograph).	American Museum of Natural History.	12,000	Do.
Wildlife Disease (primary journal in microform).	American Institute of Biological Sciences.	11,274	November 1958.
Mosquitoes of the South Pacific (monograph)	University of California	6,000	Do.
Catalog of the Nomoptera of the World	North Carolina State College.	39,200	December 1958.
Refund and adjustments		−31,460	
Total for fiscal year 1959		937,474	

RESEARCH ON SCIENTIFIC INFORMATION PROBLEMS

Mr. YATES. We shall insert page 157 in the record, showing that the amount for research on scientific information problems is estimated at $1,190,000 this year, which is an increase of $290,000 over 1960.

(The page referred to follows:)

Research on Scientific Information Problems, $1,190,000

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Research on information processing:			
Information organization and searching	$621,225	$410,000	$520,000
Mechanical translation	154,350	350,000	500,000
Subtotal, research on information processing	775,575	760,000	1,020,000
Studies of information requirements of scientists	6,100	100,000	150,000
Research conferences	0	40,000	20,000
Program total	781,675	900,000	1,190,00

All available evidence indicates that scientific and technological information is growing in total volume and in diversity of form and subject matter faster than it can be effectively collected, correlated, and disseminated. In addition, there is a large and growing segment of important research which is reported in languages not commonly used by American scientists and engineers.

The Foundation has established this program to support research directed toward at least partial resolution of these scientific information problems by the development of high-speed electronic and mechanical systems for handling, storing, and retrieving information and for translating scientific texts from one natural language to another. The more immediate goals of this program are to obtain a deeper understanding of the information requirements of scientists, to compare the effectiveness of existing information systems, to devise ways of using mechanical aids to help in analyzing and organizinfi scientific information, and to conduct preliminary development of systems for the mechanized production of translations. The long-range goals of the program are: The development of systems as fully mechanized as possible, for processing, storing, and searching through very large volumes of information; and, the mechanized preparation of accurate and readable translations of foreign materials into English.

In carrying out this program, the Foundation awards grants and contracts for research to university and other research groups as part of its overall mission of encouraging a generally greater level of research in the field and of achieving close coordination with all interested organizations and individuals.

Mr. Yates. What is the purpose of this?

Dr. Adkinson. The purpose of this is to do research on how to handle information. It is largely oriented toward: Can we translate mechanically so that we can do it much more rapidly?

Mr. Yates. The purpose of this program is to try to find out how to do your job more efficiently?

Dr. Adkinson. If the chairman wishes, I can show you an example of mechanical translation as it stands today.

Mr. Thomas. This raises the bill to $11 million.

Dr. Adkinson. This is a part of the original total of $7 million.

Mr. Yates. This example that you have handed us is the way that it comes out of a machine?

Dr. Adkinson. The upper part comes out of a machine; the lower part is what a human did.

Mr. Yates. What savings will this achieve?

Dr. Adkinson. If we can get this to work—and the research people in the field who know their business think we can—it means we can translate half a million words a day instead of a few thousand. That would be the difference.

Mr. Thomas. Let us meet in the morning at 10 o'clock and we will try to finish by 1 o'clock so that you can get back to your office.

We thank you for coming up and being so patient with us.

THURSDAY, MARCH 3, 1960.

Mr. THOMAS. The committee will please come to order.

Let me reiterate about the fine quality of this budget. It is a work of art. We have seen a lot of budgets in here every year, but I think this is by far the best one we have seen. Do you not agree, Mr. Boland?

Mr. BOLAND. Yes.

Mr. THOMAS. It is complete and in detail. The staff deserves a lot of credit.

Dr. WATERMAN. Thank you very much.

SUPPORT OF SCIENTIFIC MANPOWER

Mr. THOMAS. The first item is support of scientific manpower, where you are requesting $69,675,000.

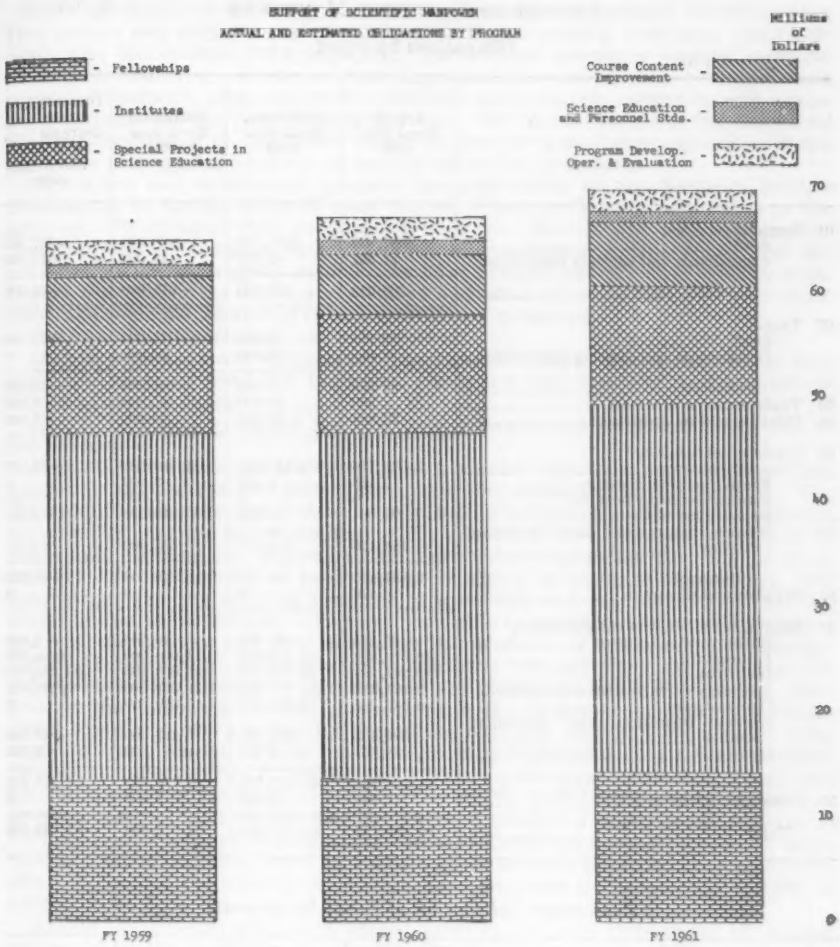
We will insert into the record at this point pages 172 through page 179.

(The pages referred to follow:)

SUPPORT OF SCIENTIFIC MANPOWER, $69,675,000

Summary—Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease, fiscal year 1961 over 1960
Fellowships	$13,070,838	$13,100,000	$14,000,000	+$900,000
Institutes for science and mathematics teachers	33,247,999	33,250,000	35,000,000	+1,750,000
Special projects in science education	8,940,905	11,171,400	11,300,000	+128,600
Course content improvement	6,030,325	6,000,000	6,000,000	0
Science education and personnel studies	780,285	955,917	1,000,000	+44,083
Program development, operation, and evaluation	2,285,432	2,258,115	2,375,000	+116,885
Total	64,355,784	66,735,432	69,675,000	+2,939,568


SUPPORT OF SCIENTIFIC MANPOWER
ACTUAL AND ESTIMATED OBLIGATIONS BY PROGRAM
Millions of Dollars
Fellowships
Institutes
Special Projects in Science Education
Course Content Improvement
Science Education and Personnel Stds.
Program Develop. Oper. & Evaluation
70
60
50
40
30
20
10
0
FY 1959
FY 1960
FY 1961

Support of Scientific Manpower

Obligations by object

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
01 Personal services:				
Staff	$687,422	$891,000	$928,000	+$37,000
Consultants and division committees	21,891	34,000	48,000	+14,000
Subtotal	709,313	925,000	976,000	+51,000
02 Travel:				
Staff	33,964	53,000	73,000	+20,000
Consultants and division committees	18,615	28,000	28,000	0
Subtotal	52,579	81,000	101,000	+20,000
03 Transportation of things	980	10,000	11,000	+1,000
06 Printing and reproduction	22,605	27,000	30,000	+3,000
07 Contractual services:				
Administrative	1,379,106	1,138,000	1,186,000	+48,000
Employee life insurance	2,156	3,000	3,000	0
Employee health benefits	0	0	7,000	+7,000
Security investment	22,094	16,000	10,000	−6,000
Science education and personnel studies	484,120	575,917	573,000	−2,917
Subtotal	1,887,476	1,732,917	1,779,000	+46,083
08 Supplies and materials	270	0	0	0
11 Grants, subsidies, and contributions:				
Employees' retirement	35,515	47,000	49,000	+2,000
Fellowships	13,070,838	13,100,000	14,000,000	+900,000
Institutes	33,247,999	33,250,000	35,000,000	+1,750,000
Special projects in science education	8,921,192	11,171,400	11,300,000	+128,600
Course content	6,030,325	6,000,000	6,000,000	0
Science education and personnel studies	296,165	380,000	427,000	+47,000
Other	78,531	9,115	0	−9,115
Subtotal	61,680,565	63,957,515	66,776,000	+2,818,485
15 Taxes and assessments	1,996	2,000	2,000	0
Total	64,355,784	66,735,432	69,675,000	+2,939,568

Percentage distribution of funds by program

	Actual percent, fiscal year 1959	Estimate percent, fiscal year 1960	Estimate percent, fiscal year 1961
Fellowships	20.3	19.6	20.1
Institutes	51.7	49.8	50.3
Special projects in science education	13.9	16.8	16.2
Course content improvement	9.4	9.0	8.6
Science education and personnel studies	1.2	1.4	1.4
Program development, operation, and evaluation	3.5	3.4	3.4
Total	100.0	100.0	100.0

The fiscal year 1961 budget distribution reflects the Foundation's latest appraisal on how it can contribute to improving education in the sciences. Basically, the level of support provided for scientific manpower programs during fiscal years 1959 and 1960 would remain about the same during fiscal year 1961. Of the approximate $2.9 million increase ($69.6 million in fiscal year 1961 compared to $66.7 million in fiscal year 1960), $2.4 million is required to cover anticipated increased costs (travel, tuition, dependency allowance, equipment allowance, indirect costs, and operating costs), $400,000 is attributed to modest program expansion, and approximately $100,000 is for increased administrative expenses.

Over two-thirds of the support of scientific manpower estimate for fiscal year 1961 covers two major areas of program activity; namely, institutes (50.3 percent) and fellowships (20.1 percent). Three other programs (special projects in science education, course content improvement, and science education and personnel studies), plus support for program development, operation, and evaluation account for the remaining 30 percent. The funds requested for increased program requirements ($400,000) would be used for a moderate expansion of the institutes and special projects in science education programs.

Significant and substantial progress has been made by the National Science Foundation in finding ways to meet the mounting problems of education in the sciences. Working in close cooperation with the scientific and educational communities, the Foundation has developed and established techniques and approaches which show great promise, or have already proved their effectiveness. Others are still in the exploratory stages and with minor refinements will probably take their places among future established programs.

The Foundation's present task is twofold:

(1) To expand these established programs to more effective levels to help meet the growing need for improved education and training in the sciences within available funds.

(2) To continue to search for new approaches to the problems which are as yet unresolved.

A number of events, all accelerating at a greater rate than had been expected, focus on the need for providing the support for education in the sciences. For example, the unprecedented rate of advance in technology which has projected this country into the space age, and which could not have been envisaged 5 or 10 years ago. Among the factors which have been responsible for this progress are (1) the investment in basic research which is constantly providing new knowledge; (2) the growing resource of scientists and engineers, both in basic research and in technology, who have been able to capitalize on new knowledge; and (3) the defense and civil needs for the products of science and technology.

Other fundamental developments which have affected the need for improved science education have been parallel and are closely related. For several years prior to the launching the first earth satellite, the ability of the American educational system to serve a rapidly expanding national need had been under close study in many places. There has been growing agreement that the educational process as reflected in our public and private systems of education, which had been adequate for our national needs in the 1930's, would not be adequate for our growing current and future needs. Critical problems of national defense in 1957 and 1958 focused attention on these problems as a major national issue. During 1958 and 1959 a series of reports all pointed to the same general conclusion that immediate and vigorous steps must be taken to improve the quality of education in America.

Among the general principles agreed upon at the 1958 Parliament of Science sponsored by the American Association for the Advancement of Science was the following:

"The primary goal of education is the intellectual development of the individual. The primary need of education is to employ quality and to raise standards of teachers, of curriculums, and of what is expected of students."

In the assignment of funds for the improvement of education, first priority should go to improvements in curriculums, teaching, and the status and salaries of teachers.

Late in 1958, Dr. James Bryant Conant completed his 2-year comprehensive study of the American high school. Dr. Conant made a number of recommendations for improving public secondary education, "without any radical changes in the basic pattern." Dr. Conant's recommendations included provision for a considerably intensified program of academic instruction for capable high school students.

In the widely heralded report on education of the Rockefeller Brothers Fund, "The Pursuit of Excellence—Education and the Future America," the importance of science education was underscored in these words:

"The heart of the matter is that we are moving with headlong speed into a new phase in man's long struggle to control his environment, a phase beside which the industrial revolution may appear a modest alteration of human affairs * * * we need an ample supply of high caliber scientists, mathematicians, and engineers. Quantitative arguments over the shortages of these fields are beside the point. We need *quality* and we need it in considerable quantity."

The Foundation's programs for the support of education in the sciences have, since the beginning, emphasized quality. Graduate fellowships have been awarded to those applicants who have demonstrated the highest potential; grants for summer institutes for high school science and mathematics teachers have been made to those institutions whose proposals showed the greatest promise of substantial results: grants for course-content studies have been made to scientists of the highest caliber who have assembled working groups of scientists and science teachers at high levels of competence and who have pursued their objectives in a thorough and fundamental way.

In the period from 1951 to 1958, before there was a general realization that science education must be supported at higher levels than had previously been thought necessary, the Foundation had available approximately $28 million, or an average of $4 million per year, for programs in support of scientific manpower. Support at that level, even at that time, was considered by the National Science Foundation to be minimal and "experimental" in the light of the general evaluation of the problems in science education.

During fiscal year 1958, after the launching of the first Russian earth satellite, it was necessary to reevaluate the national need for improvement of science education, and to reestimate the level of support required by the Foundation so that the programs in science education could be increased in scope and magnitude—to a level more nearly commensurate with the national needs. The role of NSF was always conceived of as a supplementary one, and no suggestion was ever made that the Foundation should seek to obtain funds sufficient to solve all the recognized problems in science education. However, as was stated in the fiscal year 1958 supplemental request, "It is now generally agreed that this Nation's programs in science education must be accelerated and expanded." Support, therefore, was increased to approximately $20 million in fiscal year 1958, while nearly $64 million was available in fiscal year 1959 for the expansion of old programs and the development and launching of new programs. The fiscal year 1960 congressionally approved program for support of scientific manpower remained at approximately the same level ($66.7 million), as has also the fiscal year 1961 request ($69.6 million).

There is much evidence that the science education programs which the Foundation has administered in the past are effective. We propose to continue along these same general lines expanding our proven programs to new and more effective levels, and inaugurating new approaches which show promise of strengthening further the whole structure of science education.

The Foundation's activities designed to improve science education are in the following basic areas: (1) Identification and motivation of high-caliber students in science, mathematics, and engineering; (2) financial support for further training for graduate students and advance scholars; (3) supplemental training of teachers of science, mathematics, and engineering at all levels in the educational system; and (4) the improvement of the subject matter of science instruction. In addition, the need for collection, analysis, and evaluation of information about supply-demand relationships and about education and training with respect to scientific and technical personnel continues to increase.

Our national need for the results of scientific research and development continues to grow, as does the need for highly qualified workers in scientific and related fields. This has increased the pressures on our educational system for production of highly trained scientists and technologists beyond all previous expectations. It has also increased the urgency to find solutions to the paradoxical problem of how to cope with rapidly expanding enrollments without losing quality of instruction. There appears to be no doubt that our efforts as a nation to bolster science education at its most vulnerable points must be substantially accelerated.

In view of the pressing need for accelerated effort to improve this Nation's scientific manpower position, the 4.3-percent increase requested in the fiscal year 1961 budget estimate for the support of scientific manpower represents a very nominal rise in level of operation (from $66.7 million to $69.6 million) over the estimate for fiscal year 1960. The continuing and increased requirements of this program are due to a number of factors including:

(1) Certain "built-in" cost factors which require an increased level of support merely to maintain the same program level in fiscal year 1961 as in fiscal year 1960. Approximately $2.4 million of the requested $2.9 million increase will be required to support these "built-in" cost factors.

(2) The increasing importance of maintaining, and if possible improving, the relative international standing of the United States in basic and applied science.

(3) The capability of the Foundation to assume more responsibilities as program needs and requirements become more apparent, and as means to effectively meet these needs are identified and developed.

(4) Increasing recognition that much larger problems loom ahead. Population increases with an attendant need for greatly expanded school facilities promise to multiply the problems of science education manifold.

(5) Recognition of the fact that our current educational system, in its normal growth and adjustment to postwar conditions, has not in all cases been able to keep pace with the growing need for both greater numbers and higher quality of workers in certain scientific and technological fields.

(6) Increased recognition that our national welfare, security, and existence depend more and more upon the results of scientific research and development.

Mr. THOMAS. You are asking for an increase of $2,939,568 over last year. In 1959 you had $64,355,784.

This program in its entirety has not grown in proportion to some of your others?

Dr. WATERMAN. No, sir.

Mr. THOMAS. For fellowships you show in 1959, $13,070,838; a slight increase for 1960, and for 1961, $14 million. The estimate is for a $900,000 increase over 1960.

Dr. WATERMAN. I would like to remark this committee saw the importance of this program before sputnik and acted accordingly. Its origin goes gack before sputnik. We really got started then.

Mr. THOMAS. You are always gracious and any time you brag on this committee we are not going to deny you.

For the Institutes for Science and Mathematics Teachers, in 1959 you had $33,247,999. That held at approximately the same figure for 1960, and this year it has been increased to $35 million.

Now in three or four of your programs, we are going to need some explanation because it looks to me like they are a complete duplication of some other parts of your program.

The first is special projects in science education where you are requesting $11,300,000, or an increase of $128,600 over 1960.

Next, course content improvement. It was $6 million last year and this request is for $6 million.

Then science education and personnel studies. You had $780,285 in 1959, for 1960 you estimate $955,917 and now you round it out at $1 million, or an increase of $44,083.

Last is program development, operation and evaluation. That is your administrative cost. You are requesting $2,375,000, or an increase of $116,885 over 1960.

UNOBLIGATED BALANCES FOR SPECIAL PROJECTS

Now, what is your unexpended balance for "special projects in science education"? For 1960 you had $11,171,400.

Mr. SHEPPARD. $1,888 at the end of fiscal year 1959.

Mr. THOMAS. What are your obligations up to January 1?

Mr. SHEPPARD. $4,272,554.

Mr. THOMAS. What will be your unobligated balance at the end of the fiscal year 1960?

Mr. SHEPPARD. It will be small again. It will be down to a few thousand again this year.

Mr. THOMAS. What about your course content improvement? What will be your unobligated balance at the end of the fiscal year for that?

Mr. SHEPPARD. We used it all this past year. At the end of December we had obligated about $2,196,000.

Mr. THOMAS. What about your science education and personnel studies? What would be your unobligated balance at the end of the fiscal year 1960?

Mr. SHEPPARD. We have already obligated 51 percent and I think it would be down to a few thousand dollars at the most. The obligations for most of these programs occur in one, two or three periods during the year when we obligate the major part in a lump sum.

FELLOWSHIPS

Mr. THOMAS. We will now take up fellowships, where you are asking for $14 million. We shall insert pages 180 and 181 in the record at this point, and also page 182.

(The pages referred to follow:)

FELLOWSHIPS, $14 MILLION

SUMMARY

The fellowship programs of the National Science Foundation are organized to identify those individuals at the graduate and postdoctoral levels who have the greatest scientific potential and to afford them the opportunity to continue their education.

Obligations—Number of fellows

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
TYPE OF FELLOWSHIP				
Graduate	$3,185,459	$3,345,000	$3,672,000	+$327,000
Number of fellows	1,029	1,100	1,100	0
Cooperative Graduate	$3,685,300	$3,838,000	$4,250,000	+$412,000
Number of fellows	961	1,000	1,000	0
Summer fellowships for graduate teaching assistants	$513,763	$550,000	$555,000	+$5,000
Number of fellows	563	600	600	0
Postdoctoral (regular)	$1,115,850	$1,117,000	$1,200,000	+$83,000
Number of fellows	163	163	163	0
Postdoctoral (senior)	$767,584	$850,000	$850,000	0
Number of fellows	77	80	80	0
Science faculty	$2,327,592	$2,000,000	$2,073,000	+$73,000
Number of fellows	297	268	270	+2
Secondary school teachers	$1,475,290	$1,400,000	$1,400,000	0
Number of fellows	581	550	550	0
Total	$13,070,838	$13,100,000	$14,000,000	+$900,000
Total number of fellows	3,671	3,761	3,763	+2

As shown by the table above, the fiscal year 1961 fellowship program estimate of $14 million is $900,000 or 7 percent above the fiscal year 1960 program. In terms of number of fellowships granted, however, the number of fellows remains virtually the same for both years (3,761 for fiscal year 1960 and 3,763 for fiscal year 1961). The additional funds are needed to support the same number because of an expected increase in average costs per fellow. The estimated average cost per fellow in fiscal year 1960 is $3,483. For fiscal year 1961 the average is estimated at $3,720. The anticipated increase of $237 per fellow is due to: (1) Increases in stipend and dependency allowances, (2) increases in estimated tuition and fees, (3) a rise in travel costs resulting from the mileage rate being increased from 6 to 8 cents per mile, and (4) increases in average special allowance costs.

Certain significant aspects of the overall fellowship program are presented in the tables which follow. Table I depicts the number of applicants and the number of acceptances (fellows) each year by type of program since awards were made in fiscal year 1952. Since fiscal year 1952 there has been a steady increase both in the number of applicants and in the number of awards. The major expansion occurred in fiscal year 1959 when the programs of secondary school teachers, cooperative graduate and graduate teaching assistants fellowships were initially offered by the Foundation. Of the 2,323 increase in number of fellows in fiscal year 1959 over fiscal year 1958, 2,105 or 91 percent of the increase in number of fellows was from these new programs. It is planned to maintain approximately the same number of fellowship awards in fiscal year 1961 as in 1960.

Table II shows the distribution of fellowship applicants and awards offered by type of program for fiscal years 1952 through 1959. By comparing the fiscal year 1959 awards shown on tables II and III with the number of acceptances (fellows) during fiscal year 1959 as reflected on table I, it will be noted that of the total of 3,937 fellowship awards offered 3,671, or 93 percent, were accepted. This represented a higher acceptance rate than in previous years (87 percent in fiscal year 1958). Table II also shows the scope of the seven fellowship programs in terms of numbers of applicants and awards offered in each program. More than half of the applicants and awards offered are concentrated in two programs—namely, graduate and cooperative graduate. The fiscal year 1961 budget request also places major emphasis on these two areas, both in terms of funds requested ($7.9 million out of $14) and in number of fellowships to be granted (2,100 out of 3,763).

Table III depicts a summary of awards offered by field of study for fiscal year 1959. Of all the applicants for fellowships during fiscal year 1959 only 32 percent received awards. By field of study the percentage of applicants receiving awards were: Life sciences, 28.9 percent; physical sciences, 33.7 percent; social sciences, 21.1 percent; and general science, 29 percent. Over two-thirds of the applicants (8,488 out of 12,304) were in the physical sciences field of study, while most of the rest were in the life sciences (3,344 out of 3,816). It is interesting to note that 63 percent of all applicants (7,776) were in 4 areas of the physical sciences, chemistry (2,310, of which 31.6 percent received awards), physics (1,903, of which 34.8 percent received awards), engineering sciences (1,794, of which 31.1 percent received awards), and mathematical sciences (1,769, of which 38.9 percent received awards).

Mr. THOMAS. You had 3,671 fellowships in 1959, 3,761 in 1960, and you increase it by 2 for 1961—3,763.

How is your program working out generally? What is the value of it?

Dr. WATERMAN. It is working out very well indeed. We think it is of the right order of magnitude. These fellowships are very much in demand. They are highly selective, so we are really getting the top few in the different fields. It is having the same effect which the original fellowships had in the National Academy of Sciences in the 1920's.

Mr. THOMAS. Let me read a paragraph from page 187 in the record at this point.

(The paragraph was read as follows:)

Program policies.—Section 10 of the National Science Foundation Act (as amended by Public Law 86-232) authorizes the Foundation to offer fellowships and prescribes certain provisions that shall govern their administration. Among the latter are the following: (1) the fellows shall be selected by the Foundation solely on the basis of ability; (2) the fellows shall have freedom of choice of their institutions from among appropriate nonprofit American or nonprofit foreign institutions; (3) when there are several applicants judged to be of substantially equal ability and there are insufficient funds to offer a fellowship to each, the awards shall be offered in such a way as to achieve an equitable geographic distribution; and (4) the awards may be offered for scientific work or scientific study in the mathematical, physical, medical, biological, engineering, and other sciences. The fellowships awarded under the authority of section 10 are limited to citizens of the United States.

FELLOWSHIPS IN FOREIGN COUNTRIES

Mr. THOMAS. Now, how many go to the colleges and universities in the United States and how many go to foreign countries? I notice that you are spending a little money in France, Canada, and in one or two other foreign countries.

Dr. DEES. Practically all of the predoctoral fellows study in this country. The postdoctoral people who are more advanced and who can profit from studying overseas go to a number of outstanding foreign laboratories. In the regular postdoctoral program roughly one-third to 44 percent traditionally have been studying overseas.

With regard to the senior postdoctoral program, slightly over half of the fellows have been studying overseas.

Mr. THOMAS. What countries are the most popular?

Dr. DEES. Great Britain; France gets a good many, particularly in mathematics; the low countries have outstanding people at Niels Bohr's Institute, and a good many go to CERN in Switzerland, the special international research institute there.

Mr. THOMAS. Repeat that percentage for predoctoral and postdoctoral.

Dr. DEES. In the predoctoral programs my recollection is that last year there were only some 17 NSF predoctoral fellows studying overseas out of more than 2,000, so that would be a fraction of a percent.

Of the regular postdoctorals, the fraction choosing to study overseas in the last 3 years has been 44 percent.

Mr. THOMAS. How many postdoctorals are there this year?

Dr. DEES. 163 for the current fiscal year.

Mr. THOMAS. You set out 80 here rather than 163.

Dr. DEES. This is the number of senior postdoctoral fellows. The line above deals with the regular postdoctoral program.

Mr. THOMAS. Yes, 163. About 40 percent of these are overseas?

Dr. DEES. Our average for the past 3 years has run about 40 percent of the regular postdoctorals. My recollection is, without having the detailed facts before me, that approximately 75 percent of the senior postdoctorals have been choosing to study overseas.

Mr. THOMAS. What is the motivating factor behind their choice?

Dr. DEES. Basically the fact that overseas study enables them to determine the latest thinking in the very advanced fields in which these fellows have been working, and provides an opportunity for the fellows to confer with the outstanding scientists overseas that they normally would not have an opportunity to confer with here. These people would normally have an opportunity to talk with their American colleagues, especially at the national meetings of their own societies but they do need the opportunity of talking with their colleagues overseas, many of whom are the outstanding people in the world in their special fields.

Mr. THOMAS. I have heard some high-placed Germans lament that by virtue of the destruction in World War II Germany was years and years behind the United States and some of the other countries in research. Does that same general thinking apply to England and France?

Dr. WATERMAN. They have made a very strong comeback. It has not been so true of England because England did carry on pretty well. France, of course, was hard hit, but they have comeback quite a bit,

and Germany even more. They have been able to outfit their laboratories and provide places to work. They have some very good people, including Nobel prizewinners.

Mr. THOMAS. That is not what the Germans told me last summer. They said that they had no funds for research and development, they had no funds for equipment—and I mean sizable amounts to put them back in the spotlights.

Dr. WATERMAN. They are not up to our standards on that, but a good man will get things done one way or the other.

Mr. THOMAS. I am just wondering if a little differential in the exchange rate might not add a little luster to the doctorate coming from England, France, or Germany. I imagine that there is a little element of truth there, but when it comes down to substance does he have as much to offer as we do here at home?

Dr. WATERMAN. It is different, I think.

Mr. THOMAS. The difference adds a little luster, but is that difference one of substance or luster?

Dr. WATERMAN. Substance. There is something we can get from the leading men of the world that we cannot get elsewhere.

Mr. THOMAS. Are they leading to the extent of 40 and 60 percent over the country? That is what your percentages show.

Dr. WATERMAN. Well, I think, as Dr. Dees says, this is an opportunity to confer with leading men elsewhere who are really good. They can think as well as we, and they are really tops. Our senior people can confer with each other in this country at any time.

Mr. THOMAS. Certainly neither England, France, nor Germany is spending in proportion to what this country is spending in the field of scientific investigation and research.

Dr. WATERMAN. I am not sure about that. I think the United Kingdom proportionately may be spending at about the same level as the United States.

Mr. THOMAS. Do you have any accurate information on what they are spending?

Dr. WATERMAN. Not at this time. Dr. Perlman had trouble getting in, but he is initiating studies of research and development funds abroad. We are getting some information. On the basis of 1956 data the United Kingdom spent about 1.7 percent and the United States 1.8 percent of their gross national product.

Dr. KELLY. The added cost of oversea travel for NSF fellows represents a very small percentage of the funds used for the fellowship—not more than about 3 percent, I believe.

Mr. THOMAS. It might be well be well to put the table on page 185 in the record at this point.

(The table referred to follows:)

FELLOWSHIP PROGRAMS, FISCAL YEAR 1959

Summary of awards offered by field of study

Field	Total applicants	Awards offered								Percent of applicants receiving awards
		Graduate	Cooperative graduate	Graduate teaching assistants	Postdoctorate, regular	Postdoctorate, senior	Science faculty	Secondary school teachers	Total	
Life sciences:										
Agriculture	214	4	17	4	2	3	6	1	37	17.3
Anthropology	164	16	12	10	8	4	1	0	51	31.1
Biochemistry	387	30	38	13	16	11	6	9	123	31.8
Biophysics	60	9	3	1	4	1	2	0	20	33.3
Botany	319	17	18	22	6	1	13	12	89	27.9
General biology	362	10	7	3	2	1	7	87	117	32.3
Genetics	169	19	20	8	2	6	2	1	58	34.3
Medical sciences	271	11	10	6	10	4	9	0	50	18.4
Microbiology	206	11	13	8	3	0	7	5	47	22.8
Psychology	385	30	52	29	5	2	4	0	122	31.7
Zoology	807	59	48	61	15	7	26	35	251	31.1
Subtotal	3,344	216	238	165	73	40	83	150	965	28.9
Physical sciences:										
Astronomy	67	13	5	0	0	0	2	1	21	31.3
Chemistry	2,310	201	205	162	36	12	32	82	730	31.6
Earth sciences	633	75	50	39	7	4	9	11	195	30.8
Engineering sciences	1,794	175	233	59	3	5	83	0	558	31.1
Mathimatical sciences	1,769	143	128	71	30	6	58	253	689	38.9
Physics	1,903	259	178	62	42	13	33	76	663	34.8
General	12	0	0	0	0	0	1	0	1	8.3
Subtotal	8,488	866	799	393	118	40	218	423	2,857	33.7
Social sciences	279	18	13	22	3	3	0	0	59	21.1
General sciences	193	0	0	0	0	0	1	55	56	29.0
Total	12,304	1,100	1,050	586	194	83	302	628	3,937	32.0

Mr. THOMAS. This table gives a quick preview of the subjects in which they are taking their advance training—life sciences, physical sciences, and social sciences.

SUMMER FELLOWSHIPS FOR SECONDARY SCHOOL TEACHERS

Let us take a look at your summer fellowships. The average stipend, plus allowance for travel and tuition is, about $2,545. The number of awards is 550. How is this program doing?

Dr. WATERMAN. This is quite good, Mr. Chairman.

Mr. THOMAS. Are you taking care of the schoolteachers in the summer?

Dr. WATERMAN. That is right. This permits them to improve their educational background in the sciences during the summer.

Mr. THOMAS. How do you pick these people?

Dr. DEES. This program is a very successful one, Mr. Chairman; for the first time in our teacher-training efforts, this program makes it possible for really able teachers with intellectual capacity to take advantage of graduate training of standard caliber. The summers of study have been averaging slightly over two. We select these people in cooperation with the American Association for the Advancement of Science. They have assembled each of the 2 years that we have been selecting these fellows a group of outstanding scientists to

go over the complete dockets that each candidate submits. This year we had about 2,200 candidates for approximately 500 awards that will be made next week.

SUMMER FELLOWSHIPS VERSUS NATIONAL DEFENSE EDUCATION ACT FELLOWSHIPS

Mr. JONAS. How does this program differ from the National Defense Education Act fellowships program?

Dr. DEES. The NDEA fellowships are available for the same purposes primarily that we include in our predoctoral and cooperative graduate fellowships programs. The difference lies in the fact that, first, the NDEA awards are in all fields, not just science.

Mr. JONAS. But it includes science.

Dr. DEES. It includes science.

Second, the institutions apply for the funds in this case and the awards are made basically to the universities. They, in turn, select the fellows who are to study with them and the Commissioner of Education ratifies the selection made at the institution.

Mr. JONAS. You follow a different course. You make the grant to the individual?

Dr. DEES. Yes.

Dr. WATERMAN. And this is on a national basis; it is not done by the local institutions.

Mr. JONAS. Is not this a duplication of effort? Should not all be consolidated in one for the sake of administrative savings?

Dr. WATERMAN. I would think that the two are complementary because the national fellowship program has some advantages; it has prestige and one could look at all the people in the country and pick out those most capable and give them this type of fellowship. The other is important because the institution can select its own. I would think there is no bad competition between them. Also, as you know, the NDEA fellowships are oriented strongly toward teaching.

Mr. JONAS. I do not think that we ought to make the mistake of providing educational opportunities only for the gifted students because the mediocre, or the middle-of-the-road or the run-of-the-mine people are the ones who run the country.

Mr. THOMAS. We pay the bill and we dominate the country. These A-plus students do not think so.

Dr. WATERMAN. That is part of our philosophy. We think something should be done for both groups, and therefore the two programs are complementary.

Mr. JONAS. You are restricted by your act. You have to put a premium on ability?

Dr. WATERMAN. Yes. I think that that is a desirable thing. After all, we do want the leaders to come along as well as they do in other countries.

Dr. KELLY. These are not scholarships. These are for the teachers who are going to influence all of the people. The better the teacher the better job he can do.

Mr. JONAS. That is just exactly what the NDEA is for, for the teachers. It is not for the student. I just wonder why it would not be better to have all of this entire program operated under one organization instead of two or three different ones.

Dr. WATERMAN. We keep in close touch with the Office of Education. We each have liaison people who attend meetings and confer with the Commissioner of Education on all of these matters.

INSTITUTES FOR SCIENCE AND MATHEMATICS TEACHERS

Mr. THOMAS. We will now take up "Institutes for science and mathematics teachers," and we shall insert pages 210 through 213 in the record at this point.

(The pages referred to follow:)

INSTITUTES FOR SCIENCE AND MATHEMATICS TEACHERS, $35,000,000

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
TYPE OF INSTITUTE				
Summer institutes:				
Secondary school teachers	$19,617,618	$19,250,000	$19,900,000	+$650,000
College teachers:				
Institutes	1,952,769	2,000,000	2,100,000	+100,000
Conferences	260,410	200,000	300,000	+100,000
Technical institute personnel	67,600	100,000	100,000	0
Elementary school personnel	470,300	500,000	500,000	0
Subtotal	22,368,697	22,050,000	22,900,000	+850,000
Academic-year institutes:				
Secondary school teachers	8,799,450	9,000,000	9,700,000	+700,000
College teachers	138,200	140,000	340,000	+200,000
Subtotal	8,937,650	9,140,000	10,040,000	+900,000
In-service institutes:				
Secondary school teachers	1,861,052	2,000,000	2,000,000	0
Elementary school personnel	80,600	60,000	60,000	0
Subtotal	1,941,652	2,060,000	2,060,000	0
Program totals	33,247,999	33,250,000	35,000,000	+1,750,000

As reflected in the table above, the fiscal year 1961 institutes program budget request of $35 million is $1,750,000, or 5.2 percent above the fiscal year 1960 program. One million three hundred and fifty thousand dollars of this increase is in the summer and academic year institutes programs for secondary school-teachers. The number of institutes and participants requested for support in fiscal year 1961 under these programs is the same as the number budgeted for in the fiscal year 1960 program. The additional funds ($1,350,000) are needed to cover increased costs including (1) approximately $700,000 for indirect cost allowances to participating institutions, (2) $550,000 for increased travel, tuition, dependency allowance and equipment allowances costs for institute participants, and (3) $100,000 for the additional costs of institute operation and instruction, especially staff salaries.

The remaining $400,000 estimated increased for fiscal year 1961 (in addition to the $1,350,000 explained above) is in the summer and academic year institutes programs for college teachers. Two hundred thousand dollars of this amount is in the summer institutes and conferences for college teachers program, of which $125,000 will provide for an increase in the number of teacher participants, and $75,000 will be required to cover increased costs. The remaining $200,000 increase will provide training in the academic year institutes for about 57 college teachers in fiscal year 1961 (compared to 25 in fiscal year 1960), at an average cost of $6,000 per teacher. Of this amount, $175,000 is needed to support the increased number of participants, and $25,000 to provide for increased costs.

The following table is a summary of the budget estimate by educational level of the various institutes for science and mathematics teachers:

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
Secondary school teachers:				
Summer institutes	$19,617,618	$19,250,000	$19,900,000	+650,000
Academic year institutes	8,799,450	9,000,000	9,700,000	+700,000
In-service institutes	1,861,052	2,000,000	2,000,000	0
Subtotal	30,278,120	30,250,000	31,600,000	+1,350,000
College teachers:				
Summer institutes	1,952,769	2,000,000	2,100,000	+100,000
Summer conference	260,410	200,000	300,000	+100,000
Academic year institutes	138,200	140,000	340,000	+200,000
Subtotal	2,351,379	2,340,000	2,740,000	+400,000
Technical institute personnel: Summer institutes	67,600	100,000	100,000	0
Elementary school personnel:				
Summer institutes	470,300	500,000	500,000	0
In-service institutes	80,600	60,000	60,000	0
Subtotal	550,900	560,000	560,000	0
Total	33,247,999	33,250,000	35,000,000	+1,750,000

Program objectives and needs.—The National Science Foundation Institutes program is designed to improve the effectiveness of teaching in science, mathematics, and engineering, in American schools, colleges, and technical institutes.

Many of our teachers, particularly those engaged in elementary and secondary school education, are poorly equipped to teach the mathematics or science for which they are responsible in the classroom. They do not have the background to handle the subject matter they are teaching. Generally, they know "how" to teach but all too frequently they do not know "what" to teach. Too often they are assigned courses to teach outside the area of their specialty, and without opportunity to become proficient in them, instruction must suffer. Frequently, teachers although initially well prepared, do not have time to keep pace with the rapid advances of mathematics and science. Heavy teaching loads carried during the academic year, and the necessity for supplementing their income by working at outside jobs in the summers, have made it extremely difficult for teachers to become or to remain competent in their assigned subjects.

Effective teaching comes only after the instructor has mastered his subject. The more a teacher knows about his field, the more he will be able to stimulate his capable students and to direct their interest toward intelligent consideration of careers in mathematics and science.

In the past, even if a teacher had the time and could afford to go to summer school, he would have found few courses available in mathematics or science designed to meet his special needs. Today, in large part as a result of the influence of institute programs, there is an increasing effort on the part of colleges and universities to establish programs to improve the quality of the mathematics and science teaching in our schools.

The institute programs seek to improve the quailty of teaching by providing funds for (1) the major costs of construction and management of courses that are specifically designed to meet the needs of teachers, and (2) financial assistance to teachers so that they may enroll in the courses.

Operating procedures.—The individual institutes of the various kinds are designed by colleges and universities, sometimes in cooperation with professional societies. Their plans are outlined to the National Science Foundation in "proposals"—outlines of the proposed projects, descriptions of the staffs and facilities through which they would be implemented, and budgets detailing the amounts of money that would be needed. The proposals are evaluated individually for the Foundation by panels of academic scientists and mathematicians

who are noted for their teaching and research, plus outstanding high school teachers, professional educators, and industrial scientists and mathematicians. The panelists make recommendations as to those proposals which they consider to be most worthy of support and most likely to accomplish the desired aims. On the basis of those recommendations, the Foundation staff selects proposals to be supported. Grants are made to the colleges and universities selected, with the overall distribution being made in such a manner as to provide geographic and subject matter balance within the limits of the funds that can be assigned to each academic level.

Once the Foundation agrees (on the basis of the proposal submitted) to support an institute, the host institution operates the institute without detailed guidance from the Foundation. The organization, administration, and presenation of the institutes are the responsibility of the host institution. The selection of participants is made by the staff of the institute. General rules regarding courses or programs (for example, subject matter rather than methods), distribution of grant funds, and applicant eligibility, are provided by the Foundation.

Type and scope of program.—There are three principal types: Summer, academic year, and inservice. Summer programs of from 4 to 12 weeks are called summer institutes, while those shorter than 4 weeks are called summer conferences. Academic year institutes and inservice institutes meet throughout the usual school year, and the former may include summers as well. Teachers enroll full time in the academic year institutes, hence must leave their teaching duties in order to participate. Inservice institutes meet evenings or Saturdays during the academic year, and are designed so that teachers in a local area can attend without interruption of teaching duties.

The National Science Foundation-sponsored institutes began in fiscal year 1953 with two summer institutes for college teachers. The program was immediately successful, and the continuing evidence of success has resulted in rapid expansion. Institutes for high school science and mathematics teachers have been provided since fiscal year 1954; general enthusiasm for these has led to continued emphasis on the provision of such special training opportunities for high school teachers. The fiscal year 1961 program will make it possible for approximately one-fifth of the secondary school science and mathematics teachers in the country to participate in an institute, and will provide further training for about 2,500 college teachers.

Mr. THOMAS. For this item you are making a request for $35 million, which is an increase of $1,750,000 over last year.

You have a good many programs shown here. This is one program that the committee is certainly wholeheartedly going along with you on.

INSTITUTES AND PARTICIPANTS

Generally, how is the program working out? We shall insert pages 214 and 215 in the record at this point.

(The page referred to follows:)

Institutes and participants

	Actual, fiscal year 1959		Estimate, fiscal year 1960		Estimate, fiscal year 1961		Increase (+) or decrease (−), fiscal year 1961 over 1960	
	Number of institutes	Number of participants	Number of institutes	Number of participants	Number of institutes	Number of participants	Number of institutes	Number of participants
Secondary school teachers:								
Summer institutes	318	17,000	340	17,000	340	17,000	0	0
Academic year institutes	32	1,600	33	1,600	33	1,600	0	0
In-service institutes	181	9,000	190	9,500	190	9,500	0	0
Subtotal	531	27,600	563	28,100	563	28,100	0	0
College teachers:								
Summer institutes	30	[1] 1,800	38	[1] 1,800	39	[1] 1,850	+1	+50
Summer conferences	20	550	15	415	22	620	+7	+205
Academic year institutes	0	[1] 25	0	[1] 25	1	[1] 57	+1	+32
Subtotal	50	2,375	53	2,240	62	2,527	+9	+287
Technical institute personnel: Summer institutes	2	65	2	80	2	80	0	0
Elementary school personnel:								
Summer institutes	12	515	12	515	12	515	0	0
In-service institutes	11	350	10	300	10	300	0	0
Subtotal	23	865	22	815	22	815	0	0
Total	606	30,905	640	31,235	649	31,522	+9	+287

[1] Includes college teachers participating in institutes primarily for secondary school teachers.

The budget requested for institutes for fiscal year 1961 will permit the benefits of institute participation to be extended to about the same number of teachers, and will thus make possible through these teachers improved science education for their students. It should be noted that the proportion of secondary school teachers participating in institutes will not keep pace with the total number of science and mathematics teachers in the country:

	Fiscal year 1960	Fiscal year 1961
Number of secondary school science and mathematics teachers attending institutes	28,100	28,100
Number of mathematics and science teachers in U.S. secondary schools	150,000	159,000
Percentage attending institutes (no allowance for duplication)	18.7	17.7

The requested budget will permit an increase of about 13 percent in the number of college teachers participating in institutes. This increase is particularly significant because this additional and up-to-date training of college teachers is largely reflected in the basic training of prospective secondary schoolteachers who are among their students.

No increases have been projected for fiscal year 1961 in the experimental programs for the supplementary subject-matter training of either elementary schoolteachers or teachers in technical institutes.

A more detailed explanation concerning the budget requests for each category of institute supported by the National Science Foundation follows:

Mr. THOMAS. You had 606 institutes in 1959. It goes up to 640 in 1960, and to 649 in 1961. That is an increase of nine.

Now, are all of these participants teachers?

Dr. DEES. Yes.

Mr. THOMAS. In 1959, 30,905 participated. The number increased in 1960 to 31,235, and you increase that number by 287 for 1961, or a total of 31,522.

What is the length of time, 6 weeks, 8 weeks, 10, or 12? Do some go for a year?

Dr. DEES. In the summer institutes the average length of time has been about 7 weeks on the whole, but this varies from 4 weeks as a minimum up to a maximum of about 12 weeks in some institutions.

Mr. THOMAS. How many go for a year?

Dr. DEES. The total number this year, for example, is 1,600 in the academic-year institutes with all this group being high school teachers except for a total of 34, as I remember, who are people from teacher-training institutions that have been especially brought into this program because of the effect on their teaching in their own home institutions.

Dr. WATERMAN. There are 33 institutes with 1,600 participants.

Mr. THOMAS. Break this $35 million down. How much is for stipends and how much is for subsistence, travel? How much do you pay to the institutions that are giving these courses for a period ranging from 4 to 8 weeks?

You have a footnote A here. What does the "A" refer to?

Dr. WATERMAN. College teachers participating in institutes primarily for secondary school teachers.

Mr. THOMAS. What is the number of teachers who participate for 12 months?

Dr. DEES. 1,600.

Mr. THOMAS. For the whole year?

Dr. DEES. Right.

Mr. THOMAS. Out of a total of 31,235. Break down the cost right quickly for us.

Dr. DEES. For the typical institute, according to our analysis of this year's group of proposals, the total for support of participants is $47,369. The total operational cost to the institution is $17,219. The average total support to be paid to each participant in this typical institute, which is for 7½ weeks, is $894. The total cost for one participant for the period is $1,222.

Mr. THOMAS. Break it down as to the administrative cost per college and your travel and stipend cost and subsistence cost.

Dr. DEES. The stipends would represent $29,813.

Mr. THOMAS. Out of your total of $35 million?

Dr. DEES. I beg your pardon, sir. I am sorry. I have here only a sheet that gives the cost of a typical summer institute.

Mr. THOMAS. Give us that, a typical institute.

Dr. DEES. $29,813 for stipends.

Mr. THOMAS. And how many people are going to enjoy that?

Dr. DEES. 53. $14,906 for allowances for dependents; $2,650 for travel allowances; and these three figures make up the $47,369 that I have given you. This is the total then for the support of participants. In the typical institute this would be 53 participants.

Mr. THOMAS. And around $900 each?

Dr. DEES. $894.

Mr. THOMAS. We will not quibble over $6.

What are you paying to the universities or colleges for their services?

Dr. DEES. Again, speaking in terms of this typical institute, $17,219.

Dr. WATERMAN. This covers the instructing staff as well as the administrative funds.

Mr. THOMAS. What do you permit the institution to make out of this $17,219?

Dr. WATERMAN. This is nonprofit, of course.

Mr. THOMAS. What do you mean by "nonprofit?" What costs do you permit them to charge into that total of $17,219?

Dr. DEES. We have 11 categories that are permissible under the heading of direct costs. The first is the cost for the director—the man really in charge of the institute. You might compare him with the dean of the summer school in the sense that he is in charge of this.

Then there is the staff cost.

Then there are special lecturers who constitute an important auxiliary to the staff.

Then there are secretarial and clerical costs.

Then there are assistants, people who help to run the laboratory, and then the usual social security retirement, etc., which is a small percentage.

On the administrative side wholly, office supplies, printing, the necessary publicity concerning the program at the local level, expendable laboratory materials, field trips for the participants, the university or college health service fee, and miscellaneous direct costs which are again a small fraction in the typical institute.

On the basis of this series of items that I have just enumerated, the direct costs total $14,973——

Mr. THOMAS. Out of the $17,000 you say that the institutions will have a direct cost of $14,973?

Dr. DEES. That is right, and we allow 15 percent of that amount, not 15 percent on the stipend, so the total to the institution, as best we have been able to adjust, in all of these cases—and this is one of the things the staff works on extremely hard, to see to it that this is a no-gain, no-loss operation for the institution——

Mr. THOMAS. You allow them a cushion of about 15 or 20 percent then of their direct cost?

Dr. DEES. 15 percent.

Mr. JONAS. In this program you are in competition with the NDEA. Are they not doing exactly the same thing?

Dr. KELLY. No, sir.

Mr. JONAS. They just gave me a news release that I sent out to my schools inviting applicants.

Dr. KELLY. For language studies.

Mr. JONAS. I thought it went beyond language study.

Dr. KELLY. We do know about the language and the counseling features.

Dr. DEES. As a matter of fact, the NDEA act specifies their institutes are to be in language and counseling.

Mr. JONAS. Restricted to that?

Dr. DEES. Yes, because it makes reference to the National Science Foundation's summer institutes for science and mathematics.

Mr. JONAS. The program in their justification to us on the deficiency hearing a few weeks ago was entitled, "Science, Mathematics, and Foreign Language Instruction."

Dr. DEES. Yes. This is a little different, because they do have a sizable amount of money in title 3.

Mr. JONAS. $59 million.

Dr. DEES. For aid to the States in the purchase of science teaching equipment for the high schools of the country. This is quite different from the teacher training institutes.

Dr. WATERMAN. Our program antedates that NDEA program by quite a few years. As you know, this goes back some time. When the other was started there was full cooperation between our office and the Office of Education on setting it up.

SUMMER INSTITUTES

Mr. THOMAS. Summer institutes appear on page 216, and we shall insert in the record at this point pages 216 through 222.

(The pages referred to follow:)

SUMMER INSTITUTES, $22,900,000

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Secondary school teachers	$19,617,618	$19,250,000	$19,900,000
College teachers	2,213,179	2,200,000	2,400,000
Technical institute personnel	67,600	100,000	100,000
Elementary school personnel	470,300	500,000	500,000
Total	22,368,697	22,050,000	22,900,000

The development of Foundation-sponsored summer institute activity is indicated in the following table:

Fiscal year	Type	Number of institutes	Participants supported by NSF	Support provided by NSF
1953	College	2	42	$21,200
1954	Secondary school	1	26	10,000
	College	3	71	40,500
1955	Secondary school	6	126	59,000
	College	5	173	75,000
1956	Secondary school	18	750	380,000
	College	7	450	235,000
1957	Secondary school	91	4,800	5,055,000
	College	5	300	278,000
1958	Secondary school	121	6,200	6,400,000
	College	5	300	285,000
1959	Secondary school	318	17,000	19,600,000
	College institutes	30	1,800	1,950,000
	College conferences	20	550	260,000
	Technical institutes	2	65	68,000
	Elementary	12	515	470,000
1960 (estimate)	Secondary school	340	17,000	19,250,000
	College institutes	38	1,800	2,000,000
	College conferences	15	415	200,000
	Technical institutes	2	80	100,000
	Elementary	12	515	500,000
1961 (estimate)	Secondary school	340	17,000	19,900,000
	College institutes	39	1,850	2,100,000
	College conferences	22	620	300,000
	Technical institutes	2	80	100,000
	Elementary	12	515	500,000

Through 1959, more than 33,000 summer institute stipends have been awarded to science and mathematics teachers since the first National Science Foundation-supported institutes were established in 1953. It is estimated that these stipend went to at least 25,000 different individuals. Hence, about one-sixth of the secondary-school science and mathematics teachers in the Nation had participated in a summer institute by the end of 1959.

From two in fiscal year 1953, the number of summer institutes sponsored by the Foundation had grown to 126 in fiscal year 1958, and 382 in fiscal year 1959. Although the fiscal year 1960 budget is slightly smaller than that of fiscal year 1959, a total of 407 institutes will be supported by these funds, because many of the institutes have been planned for smaller numbers of participants. The total number of praticipants has remained essentially constant.

Funds requested for fiscal year 1961 will provide for a total of about 415 summer institutes, with the only increase being for 8 additional conferences and institutes for college teachers. Based on previous years' experience, it is estimated that the number of individual teachers who will apply for institute participation in fiscal year 1961 is likely to be at least 3 times as many as the number of stipends (20,000) that will be available.

Summer institutes have proved to be remarkably successful in their immediate, fundamental purpose: improving the mastery of subject matter by science and mathematics teachers in order that their classes can be better taught. They are also proving to be effective in encouraging colleges and universities to provide programs suited to the needs of teachers. Some new degree programs designed for teachers have been established.

Reasons for the success of the summer institutes include the following:

1. The institutes provide subject matter centered instructional opportunities specifically designed to meet the needs of teachers;
2. Teachers recognize that they need the subject matter provided;
3. The institutes are available at a season of the year when it is possible for teachers to attend without interrupting their own instructional duties;
4. The available financial support makes such attendance possible;
5. The financial support available to the host institutions makes it possible for them to offer especially designed programs;
6. Because host institutions are allowed considerable freedom in developing and conducting programs which they consider will be most productive and within their capabilities, many new and imaginative approaches to the further training of inservice teachers have resulted from the program;
7. In the summer, staff members and campuses are available for the institutes.

For the summer institutes, the Foundation provides funds for participant support, and instructional and management costs for the institutes and an allowance for indirect costs. Beginning in fiscal year 1961, a limited allowance will be provided for permanent equipment needed by host institutions to improve the institutes.

The support given each stipendholder includes a stipend of not more than $75 per week, a dependency allowance of not more than $15 per week for each dependent up to a maximum of four, and a travel allowance for one trip from home to institute and return.

Institute enrollment is not limited to stipendholders. Other individuals, acceptable to the institute staff, can be admitted so long as their number is not so great as to diminish the effectiveness of the institute.

A typical summer institute is 6 or 8 weeks in length and has about 50 stipendholders and several nonstipendholders. It may offer work in a single science or mathematics area, or it may include offerings in several subjects. Prominent visiting scientists supplement the local staff. The institute ordinarily provides seminars, lectures, etc., in addition to specially designed courses. Also, it ordinarily provides considerable opportunity for informal discussions between registrants, and between registrants and staff, both in and out of classrooms. These discussions and group learning are encouraged through housing registrants (and staff) in an area set aside for them, through group meals, and through informal activities such as field trips, special lectures, etc. The benefit is greatest when the registrant group is coherent, having similar problems and enrollment in a common program, but come from different regions or sections of the country, so that developments in each section can become available to others.

The first summer institutes supported by the National Science Foundation were for college teachers; since fiscal year 1956 most of the institutes have, however, been designed to meet the needs of secondary-school teachers.

Summer institutes for secondary-school teachers of science and mathematics.—From the fiscal year 1960 appropriation, 340 summer institutes for secondary-school teachers will be supported at some 265 institutions; 23 of these institutes admitted college teachers also. In most cases the period of attendance will be from 6 to 8 weeks, but in some instances it will be as long as 12 weeks. A total of 17,000 secondary-school teachers will receive stipends. Of the grants to these 340 institutes, the major portion will be used to support the teacher-participants, who during the summer would otherwise ordinarily have been employed outside of academic fields in order to supplement their incomes.

The amount requested for fiscal year 1961 is based on an estimated 340 summer institutes with 17,000 participants and direct costs of institute operation. In addition, the estimate includes an allowance for indirect costs; and a small allowance for permanent equipment.

Breakdown of fiscal year 1961 budget request for summer institutes for secondary school teachers

Fiscal 1960 level	$19,250,000
Allowance for indirect costs	550,000
Allowance for permanent equipment	100,000
Total	19,900,000

Indirect costs.—Study of the proposals for summer institutes submitted in fiscal year 1959 and fiscal year 1960 indicates that the allowances for indirect costs will amount to about 3 percent of the total amount of support granted.

Permanent equipment.—The program of summer institutes is one that involves many small colleges. These institutions frequently do not have regular laboratory classes in science as large as the institute sections. There is need for the colleges to be given funds for necessary permanent equipment, such as microscopes, balances, etc., adequately to enable the institute participants to do individual laboratory work. The $100,000 requested represents approximately one-half of 1 percent of the budget request for the program. On the assumption that one-half of the institutes supported would request equipment grants, approximately $600 is budgeted for each of 170 institutes. Adequate justification of requests for funds for the purchase of permanent equipment will be required in a separate section of the proposals.

The amount requested for summer institutes in fiscal year 1961 includes no allowance whatever for increased costs, such as higher faculty salaries or increased costs of materials. Salaries will very likely be higher than in previous years. If they are higher, the amount allotted to permanent equipment will in all likelihood be correspondingly reduced, since the only alternative would be to reduce the number of institutes or the number of participants.

Summer institutes and conferences for college teachers of science, mathematics, and engineering.—The need for aid in improving teachers' mastery of science and related subjects is by no means limited to teachers at the secondary school level. College teachers usually begin with a greater background and deeper understanding of subject matter than do secondary school teachers. But they must teach more intensive and higher level courses than do the secondary school teachers. The same factors of heavy loads and low salaries, particularly in the smaller colleges and in junior colleges, have operated over the years to result in deficiency of subject-matter mastery, exactly as in the case of secondary school teachers. College teachers ordinarily are not required to teach the disparate variety of courses demanded of secondary school teachers, but they must teach various courses in limited fields. It is even more necessary for college science teachers to be abreast of recent developments.

Many college teachers are needed to staff the summer institutes for secondary school teachers and to teach summer schools. The Foundation program for college teachers therefore provides summer conferences (less than 4 weeks in duration), in addition to the usual summer institutes (4 to 12 weeks in length). The shorter conferences are often especially advantageous for consideration of specialized but relatively limited topics in science or related fields, or recent advances in a particular area.

In fiscal year 1961, an increase of $200,000 has been requested for this program over the fiscal year 1960 funding level ($2,400,000 in fiscal year 1961; $2,200,000 budgeted for fiscal year 1960). Most of this additional request for funds would be used to support a moderate increase in the numbers of participants in institutes and conferences for college teachers during fiscal year 1961.

Such an increase is in line with the Foundation's conviction that many science and mathematics teachers in junior colleges, community colleges, teachers' colleges, and the smaller liberal arts colleges need additional help in improving their mastery of the subjects they teach, and in line with the Foundation's expressed interest in strengthening this area. Specifically, 39 summer institutes and 22 summer conferences are planned particularly for college teachers in fiscal year 1961. Approximately 1,850 institute stipends (some of these would be in institutes attended also by secondary school teachers) and 620 conference stipends would be provided for college teachers. Of the $200,000 in additional funds requested for this program, $125,000 would be used to support the increased number of teacher participants, and $75,000 would be required to cover increased indirect costs.

Summer institutes for technical institute personnel.—The lack of competent subprofessional assistants is one of the serious limitations in many areas of scientific research and in the development of technological advances. Specialists who can perform somewhat routine but exacting tasks in the preparation and performance of scientific experiments, in the intelligent recording of data, and in the maintenance and operation of complex equipment, are of inestimable importance. Many junior and even senior scientists are preoccupied with tasks which could be handled by well-trained technicians.

Increasing numbers of technicians are being trained in specialized 2-year, post secondary curriculums offered in technical institutes and some junior colleges. Faculties for these curriculums are being drawn from many sources, and many of these staff members need additional training to enable them to instruct their students effectively in the highly specialized courses characteristic of these curriculums. This additional study can best be provided through summer institutes designed for the purpose, since the needs of staff members in technical curriculums differ markedly from those of secondary school and college science and mathematics teachers.

These summer institutes are organized and administered in a manner similar to the institutes for secondary school or college teachers.

The first two summer institutes—actually a summer institute and a shorter summer conference—for technical institute personnel (including junior college teachers in technical curriculums) were held in fiscal year 1959. The total costs were $68,000 and there were 65 participants. Two longer summer institutes are planned for fiscal year 1960, with a total budget of $100,000. For fiscal year 1961, again two institutes are planned, with a requested total budget of $100,000.

Summer institutes for elementary school teachers and supervisors.—One vital area which must be strengthened if we are to be successful in improving the teaching of science and mathematics lies virtually untouched. This is in the elementary schools.

Studies show that elementary school children ask more questions about science than any other subject. Their interest in the field is enormous. However, the typical elementary school teacher has a meager background in science, and is unable to answer the questions. Her own feelings of insecurity in the subject add to the difficulty. The subject is poorly taught, if not shunned completely. By the time children reach secondary schools, many have lost all interest in science, convinced that science is difficult and not for them. Many fear the science and mathematics courses they must take. Many potential scientists of high ability are lost to the field and to the Nation. Adequately prepared secondary school teachers can help in some measure to overcome this difficulty, but it is important to remember that much of the trouble is generated in the elementary schools.

That mathematics commonly is inadequately taught in the elementary schools has been recognized for years. The teaching of science and mathematics in the elementary schools must be improved. A major contribution to this improvement can come only through improving the competence of the teachers. The teachers have already studied methods of teaching. Their deficiency most commonly is lack of knowledge in science and mathematics.

The problem is enormous. There are nearly 1 million elementary school teachers and supervisors in the country. Many lines of attack must be tried.

As one means of approaching this serious problem in the elementary schools, the Foundation supported an experimental program of 12 summer institutes for approximately 500 elementary school supervisors and key teachers in fiscal year 1959 at a cost of $470,000. A pilot program of similar magnitude will be provided in fiscal 1960, and again in fiscal year 1961.

Mr. THOMAS. You are requesting $22,900,000 for summer institutes. There is an increase of $850,000 this year over last year. There is quite a bit of detail as to the costs and so forth. How is this program working out?

Dr. DEES. This is the oldest of the institutes' programs.

This has had the strongest favorable reaction of any of our programs as far as the total number of people that have been enabled to gain training is concerned—and therefore the total number of students who have benefited from the teacher improvement that has resulted.

We have carried out a number of studies that invariably indicate the program is accomplishing what it was set up to do. It has had a great deal of commendation from all over the country.

SUMMER INSTITUTES FOR COLLEGE TEACHERS

Mr. BOLAND. With reference to college teachers you are requesting $2,100,000 for the fiscal year 1961. Why do you get into the field of teaching college teachers? I can understand teaching the secondary school teachers and that is where you spend the $19,900,000. But why do you get into the field of college teachers? I would not think that a college would want anyone as a teacher if they could not instruct. Somewhere in here I thought that I saw a reference to the fact that we are woefully inadequate and have teachers that do not know how to teach, college teachers in mathematics and science. Do you not say that somewhere?

Dr. WATERMAN. The answer is they need it. This country has a great variety of institutions. There is a very interesting situation at the small college. The studies have shown that certain small colleges, on the order of 10 percent, are doing an amazing job of turning out good scientists and engineers who go on to graduate schools at larger universities. Some colleges have been neglecting science rather badly. This is aggravated a little bit by the fact that industry wants scientists so much that it is taking competent people away from the colleges—and the smaller institutions are the ones who are vulnerable because their salaries are not high. Many college science teachers do need the training. They admit it. That is not just our finding. They want it.

Mr. YATES. I think that industry might be approached to find out whether they would loan some of their scientists for teaching in college.

Dr. WATERMAN. We have had this subject under discussion and I think that industry would be quite willing to help out. We have also tried an experimental program of taking military officers who retire early who have been in research and development work and training them for teaching. A number of them have gone into that. These are ways by which you can add to the teaching profession.

Dr. KELLY. May I add to that? It has troubled us quite a bit. There is a very serious problem here mostly resulting from the rapid enrollment in colleges. There is a severe shortage of teachers in science, mathematics, and engineering in our colleges due largely to increasing college enrollments and also due to the rapid acceleration of scientific knowledge. The teaching loads are so high that the teachers have little time to keep abreast of their field—and this sum-

mer institute program affords an opportunity during the summer for them to get abreast of their scientific field. We emphasize scientific knowledge here, not teaching methods.

Mr. BOLAND. I do not know why the National Science Foundation has to do it. This is a program that could increase tremendously in numbers. In 1953 it was supporting 42 participants, then in 1955 it was 173; 450 in 1956, then you dropped down to 300 in 1957, and then you go to 300 in 1958.

Dr. KELLY. It differs from the high school teacher program. The numbers of college teachers are much smaller than the high school teachers.

Dr. WATERMAN. One must reckon with the increasing enrollments and the problem of attracting and keeping the science teachers in a small college. They have to spend all of their time teaching and their hours go right up and that means that they have no opportunity to study the subjects except in the summer, and that is where these summer institutes come in handy.

POTENTIAL TEACHERS EMPLOYED BY PRIVATE INDUSTRY

Mr. YATES. How do you know as a fact that people who you think would make good teachers would go into industry? Have you checked this?

Dr. WATERMAN. There is quite a variable. There are some industries that would not want to take science teachers if they wanted to go. Much depends upon the qualifications of the teacher.

Mr. YATES. You stated a few moments ago that your good students, or scientists, are going into industry rather than into teaching. How do you know?

Dr. WATERMAN. Just watch the graduating classes of the universities and follow where they go.

Mr. YATES. Do you follow them and see which industries they go to?

Dr. WATERMAN. We have made studies of this. Industry is in there trying to offer them jobs.

Mr. YATES. I know that.

Dr. WATERMAN. Good ones at a high salary.

Mr. YATES. You suggested, too, that you had approached industry with regard to the possibility of permitting some of these talented scientists to be used for teaching purposes.

Dr. WATERMAN. Yes.

Mr. YATES. Did I understand you correctly?

Dr. WATERMAN. Yes. That has been under discussion.

Mr. YATES. You have not talked to industry on this?

Dr. WATERMAN. Yes.

Dr. KELLY. We know that there is a salary differential between small colleges and industry. We know that scientists and engineers behave like economic men in this respect. We have discussed this with many industrial concerns. They know for their own interests that they should keep the best people in teaching, but at the same time they desperately need able scientists now. So many of them are trying to work their way out of this dilemma. One example is offering their people as lecturers in the summer institutes that we are sup-

porting. Some of them are making arrangements where they hire people to spend a year teaching in a high school or a small college and then a year in their own industrial plant.

Mr. YATES. It is a very difficult problem for the scientists because if they have true public spirit to teach for a year, even though the industry may pay their salaries during that period, the probabilities are they will lose their positions in their firms with respect to possibilities of promotion.

Dr. KELLY. Yes.

Dr. WATERMAN. The National Education Association has made an estimate that only 12,000 college and university students will qualify for teaching certificates in science and mathematics in 1959 and that probably more than a quarter of those who do qualify for teaching will not enter teaching. They find better paying jobs, you see, even though they have qualified.

Mr. YATES. At least one-quarter——

Dr. WATERMAN. Of those who are qualified, one-quarter are expected not to enter teaching.

ACADEMIC YEAR INSTITUTES

Mr. THOMAS. Let us take a look at your academic year institutes where you are asking for $10,040,000.

We shall insert pages 223 through 226 in the record at this point.

(The pages referred to follow:)

ACADEMIC YEAR INSTITUTES, $10,040,000

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Secondary school teachers	$8,799,450	$9,000,000	$9,700,000
College teachers	138,200	140,000	340,000
Total	8,937,650	9,140,000	10,040,000

Academic year institutes for secondary school teachers.—These institutes are full-time, year-long programs of study in science and mathematics, especially designed for secondary school teachers in these fields.

The National Science Foundation supported its first two academic year institutes during fiscal year 1956. In fiscal year 1960 funds will support 33 institutes distributed over the country during the academic year 1960–61. About 1,600 or 1 percent of the science and mathematics teachers in the United States will participate.

Secondary school teachers, unlike members of college faculties, cannot as a rule obtain sabbatical leaves or similar means of financial support for purposes of further study and self-improvement. In these times of rapid development in scientific knowledge, secondary school teachers have great need of such study in order to keep up with their subjects. Many of these secondary school teachers initially lacked the sound preparation demanded today, and even if they once had it, the present situation demands continued study and effort to keep up to date.

The academic year institutes offer invaluable assistance to secondary school teachers in augmenting their mastery of the subject matter of science and mathematics. These institutes have certain distinct advantages over summer and in-service institutes. Participants in academic year institutes have an entire academic year, and in most cases an additional summer, during which they can devote full time to their studies. In this time many of the teachers can complete the requirements for a master's degree. The principal disadvantage of the academic year institutes is that teachers are removed from service for a year

while attending the institution. While this latter fact is a valid reason for not expanding this program appreciably, it should be noted that as many teachers are returned to active teaching at the close of each year's program as are taken out by the program in the following year. There seems to be general agreement that about 1 percent of the secondary school teachers may participate in this training program at a given time without creating a serious problem of replacement.

The program has been enthusiastically received by teachers, as shown by the fact that the number of applications for participation in the 1959–60 academic year institutes exceeded the number of available openings by a factor of 6 to 1.

Courses of study for the academic year institutes are planned by the colleges and universities which sponsor an institute. The host institution supplies staff and physical facilities and administers its program. Financial support for both teachers and institution is provided by a grant from the Foundation to those institutions whose proposed institutes are judged highest in quality.

The criteria used in selecting proposals for academic year institutes to be supported include: (1) caliber of instructional staff; (2) degree of interest in the program evidenced by the institution; (3) appropriateness of the courses offered; (4) plan of operation; (5) facilities of the institution (laboratories, classrooms, housing, outside activities); (6) relative cost; (7) geographical distribution and ability to reach a wide spectrum of teachers; and (8) balance of subject discipline. In the case of those institutions which are applying for renewal of an academic year institute after 2 or more years of actual operation, special consideration is given to the degree of success of the institute in meeting the objectives of the program.

For the fiscal year 1960 program, 65 proposals were received. Giving full consideration to the evaluations of these proposals by a panel of 20 well-known scientists and mathematicians, the staff of the Foundation selected 33 colleges and universities for award.

Each secondary school teacher who participates in the program does so at considerable personal sacrifice, since in a typical case the teacher must leave his job temporarily and move with his family to the location of the institute, and live on stipend and allowances considerably less than his regular teaching salary.

The subvention given each stipend holder includes: a stipend of not more than $3,000 for the academic year; a dependency allowance of not more than $450 for each dependent up to a maximum of four; a travel allowance for two round trips from home to institute; and an allowance of $50 for textbooks. For the additional summer period, the basic stipend and dependency allowance are increased on a pro rata basis according to the length of the summer program.

The Foundation also pays tuition and fees for stipend holders, plus direct instructional and management costs of the institute to the amount that these exceed the sum granted for tuition and fees. It also pays an allowance for indirect costs to the institution.

No increase in the size of the program over fiscal year 1960 is planned either with respect to the number of institutes or the number of participating secondary school teachers.

The increase in budget requested for this program reflects an actual increase in cost of the program due to three principal factors. First, the allowance paid to teachers for each dependent was increased in fiscal year 1960 from $300 to $450 for the academic year. This adjustment, the need for which has been strongly indicated by past experience, will put the allowance more nearly in line with the dependency allowances paid in other National Science Foundation programs of similar nature. It is estimated that this will increase the cost of the total program by about $450,000.

The second cause of an increase in cost is due to a change in the policy of payment of indirect costs. Previous to fiscal year 1960, indirect costs were allowed to the extent of 15 percent of the amount by which total direct operational costs exceeded the requested tuition. This often led to inconsistencies in that some schools were able to "waive" tuition and thus obtain the maximum amount of support for indirect costs, while others would receive practically no support for these costs. In the future, support will be available to all institutions sponsoring academic year institutes in the amount of 15 percent of the total direct cost of operation. The increase in the cost of the academic year institutes program due to this change in policy amounts to about $150,000. It is to be noted that most universities calculate their "indirect costs" at 20 percent to 40 percent so that universities are making a substantial contribution to the program in accepting 15 percent.

A third factor in the increase in anticipated costs of the academic year institutes program for secondary school teachers in fiscal year 1961 is that of rising cost of operation and instruction, much of which is due to the increase in staff salaries. A conservative estimate of the magnitude of this factor is $100,000. The total increase over fiscal year 1959 anticipated is thus $700,000.

The $9,700,000 requested for the academic year institutes program for secondary school teachers in fiscal year 1961 will support approximately 33 institutes, as in fiscal year 1960. The estimate for fiscal year 1961 will permit about 1,600 secondary school science and mathematics teachers to participate; roughly 1 percent of the total of these teachers in the Nation.

Academic year institutes for college teachers.—Although academic year institutes for secondary school teachers have been in operation since fiscal year 1957, there have been no similar year-long institutes for college teachers. However, beginning in fiscal year 1959, an experimental program for college teachers of science and mathematics has been supported in conjunction with the programs for secondary school teachers. Grants amounting to about $138,000 were made to three of the regular academic year institutes to enable each to support eight college teachers in its program. The need for college teacher institutes has been recognized for some time past, and the response to the experimental program has been very strong.

It has been clearly demonstrated that a considerable number of the college teachers who are giving the training in science and mathematics to prospective elementary and secondary school teachers of mathematics and science are themselves either inadequately trained or seriously out of date in these areas. This is especially true of some teachers in the teachers' colleges, certain small colleges, and even in the universities. Money and time spent in training these "teachers of teachers" can pay large dividends in the improvement of the preservice preparation of elementary and secondary school teachers. Beneficial results in the development of proper curriculums for training of science and mathematics teachers should also accrue from an improved understanding of these subject-matter areas by these college teachers.

Stipends, and dependency, travel, and book allowances are currently being planned at the same levels as for the secondary school teachers in the academic year institutes.

In this program, grants will be made for projects which follow either of two different patterns. Some institutions will wish to have a few college teachers participate in an academic year institute program along with a group of secondary school teachers. This is the type of program which is being undertaken experimentally in fiscal year 1959 and fiscal year 1960 to the extent of available funds. A typical institute of this type consists of 40 to 50 secondary school teachers and 8 to 10 college teachers working together in appropriate parts of the program.

For fiscal year 1961, it is expected that more of the institutes will make provision for a few of these "teachers of teachers," with perhaps one institute devoted entirely to college teachers. The total costs of training a teacher in this program, including stipend, allowances, and expenses of instruction, average about $6,000 per teacher, so that the requested funds for fiscal year 1961 will provide training for about 57 college teachers, whether separately or grouped with high school teachers; $340,000 will be required to support the 57 teacher participants compared to $140,000 which has been budgeted for support of 25 teachers in fiscal year 1960. Of the $200,000 requested increase (over the fiscal year 1960 program), approximately $175,000 would be needed to support the increased number of participants, and $25,000 to provide for increased indirect costs.

Mr. THOMAS. You are asking for an increase of $900,000, and I notice in justifying each of the program increases you attribute it to two things, the increase in cost of doing business with the universities and so forth, and about a fourth of that increase is due to your increase in numbers.

You have 33 of these institutes and about 1,600 people this year taking part in them.

Here is one very enlightening statement: "about 1,600, or 1 percent of all the scientists and mathematics teachers in the United States will participate in this program."

Dr. DEES. I think we have misled you here.

Mr. THOMAS. What are the numbers then? You state 1,600, or 1 percent will take part, so that means 160,000 does it not?

Dr. DEES. That is correct.

Dr. WATERMAN. 1,600 will participate.

SELECTION OF STUDENTS

Mr. THOMAS. One percent. How do you select these? Do you do it just like the others, competition?

Dr. DEES. Yes. At the institute level. The grant proposals are screened nationally.

Mr. THOMAS. Who does the selecting? Is it the institution? Or is it your Princeton board?

Dr. DEES. The institution itself.

Mr. THOMAS. In all of your institutes?

Dr. DEES. That is true.

Mr. THOMAS. What yardstick do you lay down as a guideline for them?

Dr. DEES. Basically, that they are to select people again on the basis of their ability to profit from the institute's offerings. This is a variable depending upon the goals of the institute. In some cases the institute will choose to set its sights so as to pick up bright people who have had little training in science. In other cases, they will set their goals to pick up better teachers and to make them still better.

NUMBER OF APPLICANTS CHOSEN

Mr. THOMAS. In all of your institutes, stated percentagewise, what is the number of applicants to take the courses and the number of those actually chosen to take them?

Dr. DEES. We have just completed an analysis of the applicants in the high school summer institutes this past summer. There were approximately 100,000 separate applications and over 25,000 individuals applied. This contrasts with the figure of 17,000 that were actually given places in the summer institutes.

Mr. THOMAS. Ninety percent of those who apply are given training, then?

Dr. DEES. That was true this past summer, but it is already clear from the applications that are streaming in for the summer of 1960 that probably on the order of 50,000 different people will apply for the 17,000 spaces available again this year.

Mr. THOMAS. What percentage of your total high school science teachers are actually given training?

Dr. DEES. In the summer institutes just over 10 percent. In the academic year institutes, about 1 percent, and in the so-called in-service institutes another 6 percent, roughly: so about 17 percent.

Mr. THOMAS. That is pretty good distribution, is it not? And the universities and the colleges do their own choosing.

When it comes to your fellowship program, who grades your papers and who sets the pattern?

Dr. DEES. In this case we have a contract with the National Academy of Sciences—National Research Council. They help us in a variety of ways including assembling all of the application materials and

assembling the panelists who come to Washington to form a central panel to review all of the application materials, including test results (but not exclusively the test results), and make the judgments on ability.

Mr. THOMAS. In a few words, the National Academy sets the standards for grading the papers.

Dr. WATERMAN. These summer institutes.

Mr. THOMAS. I am talking about your stipend now for your fellowship program, not your institutes. Who sets the standards? The National Academy reviews to set the standards for your fellowship program? The Princeton Board grades your papers; is that the way you work it?

Dr. DEES. Yes. We do, however, give careful and close instruction to the Academy-Council as to the standards to be followed.

Dr. WATERMAN. We really set the standards and they carry out the analysis and appraisal and recommend to us.

Mr. THOMAS. What need, then, do you have for the National Academy of Science?

Dr. WATERMAN. This avoids our doing it with our small staff and that helps. This brings in an outside group that are quite expert and call on the panels needed throughout the country. They make recommendations to us and we act on these recommendations.

Mr. THOMAS. It is good to have somebody looking over your shoulder and sort of advising you and assisting?

Dr. WATERMAN. Yes.

Mr. THOMAS. That makes sense.

GRANTS FOR REPEAT COURSES

Mr. JONAS. Dr. Waterman, do you grant stipends for institute training in successive years to the same teacher?

Dr. WATERMAN. That depends on the policy of the particular institute. Dr. Dees can give you illustrations of that and statistics, I think. In some cases it is desirable for a person to spend more than 1 year, depending on the character of the institute, and in others they believe in having a variety, but we leave this open to them, just following the distribution ourselves. Generally speaking, in the more adkvanced institutes it is desirable for the teacher to go more than 1 year. Is that not the rule, Dr. Dees?

Dr. DEES. Yes. I think perhaps it might be helpful to give you these numbers.

Up to now—or I should say, up through this coming summer—in all of the institutes' programs that we have supported there will have been a total of about 81,000 participants. We would estimate on the basis of reports that we have had from the institutes (though this I emphasize is an estimate), that approximately 50,000 separate individuals have been trained.

Mr. JONAS. Are they repeaters?

Dr. DEES. 50,000 different people out of this total of 81,000 would have received training. This means that something like 15,000 have had 2 or more opportunities under this program.

Mr. JONAS. 15,000 out of 81,000 have had an opportunity to attend more than 1 institute?

Dr. DEES. 15,000 would be my best estimate here.

Mr. THOMAS. What Mr. Jonas is asking you is whether there is any limitation where they can attend?

Dr. DEES. Only in policy. We do urge the institute directors not to make "institute bums" out of teachers.

Mr. THOMAS. What constitutes making him a bum—when he goes to more summer institutes for 8 weeks?

Dr. DEES. The judgment here depends upon his need, as we see it: An individual who really has a very responsible position in his high school but who has need for additional training should continue to receive consideration, but if he has already been to several institutes——

Mr. THOMAS. An A-plus man would go 1 year, a C man would go 1, 2, 3, or 4.

Dr. DEES. This is a matter of judgment on the part of the institute director.

Mr. JONAS. I can see where there might be an occasional exception to the rule, but when you make this opportunity available to all the secondary school teachers throughout the country I think that would be your primary mission.

Dr. KELLY. All these directors are alert to this possibility, but as the result of this summer institute the teachers now have an opportunity to study the subject matter of science and mathematics, and it is also partly as the result of this institute that they have developed a new degree.

Formerly when the teachers when back they were given an opportunity of taking only education courses and not the subject matter courses of science. Now they have the opportunity for securing master's degrees in the teaching of science and the teaching of mathematics.

RENEWAL OF FELLOWSHIPS

Mr. JONAS. Do you have a policy with respect to fellowships in this area? Do you restrict fellowships to one grant, or do you permit a fellowship holder to enjoy successive fellowships?

Dr. DEES. Our policy on renewal of fellowships is that an individual is free to reapply, but he has no assurance that he will get a renewal. This means, for example, that in the case of the highly selected people who get first-year awards—for first-year graduate study, that is—approximately 70 percent will be renewed because they have already been carefully chosen. They do good work, and therefore they are able to successfully compete afresh in the next year's competition.

Dr. WATERMAN. Perhaps Mr. Jonas means the high school teacher fellowships for summer. Do you have that in mind?

Mr. JONAS. I wonder if in all these fellowships you have a policy about repeaters. We have had this up before, but I would like to get it in the record. Do you have any assurances that the people who enjoy these fellowships and benefits from the institutes will continue in the teaching field, and what assurance do you have that you are not educating people to leave teaching and go and get high-paying jobs in industry?

Dr. WATERMAN. In the first place, the type of training that they go through is to round out their teaching.

Mr. JONAS. I want to know whether you have any assurance that when they finish they will go back to teaching.

Dr. WATERMAN. Perhaps Dr. Dees can tell you about that. I believe practically all of them go right back to the school for teaching purposes.

Mr. JONAS. As a voluntary action on their part? You have no requirement on that?

Dr. WATERMAN. No, sir; we have no requirement on this.

Dr. DEES. For example, Mr. Jonas, in our science faculty fellowship program which is for college teachers, we do ask for a moral commitment from those who apply in this program. It has been our observation that virtually everyone obeys his own moral commitment.

In the other programs we do not have any fixed requirement, but many of the teachers who apply to participate in the summer institutes have to write a little "personal essay," if you please, on their goals; they often make a commitment to return to teaching to the institute to which they apply—and this is considered in choosing these people initially.

Dr. KELLY. We have some statistics which show that the rate of loss of teachers due to added training at institutes is less than the normal rate of loss of teachers.

Mr. THOMAS. What does that mean? Does it mean 90 percent, 95 percent go back to teaching?

Dr. DEES. It is of the order of 90 percent, and in some of the institutes on which we have detailed figures, we have 100 percent.

Mr. JONAS. You have not considered making a return to teaching a requirement for the receipt of a fellowship?

Dr. WATERMAN. No, we have not, other than this statement: that the man expects to return. We have thought of that question quite often in connection with fellowships, and it has been discussed as a matter of policy in the Government in various contexts. The general feeling is that this is not exactly the American way to do things; we do it, however, for military training.

Mr. THOMAS. You do not do it either at Annapolis or West Point.

Dr. WATERMAN. I think it is done in connection with the ROTC program.

Mr. THOMAS. They might sign some statement to the effect that they will pursue this career but there is nothing to prevent them from walking out as soon as they get their commission.

It is frowned upon, but still they can walk out.

Dr. WATERMAN. That is true. The ROTC is what I was thinking of.

Mr. JONAS. I was thinking if the primary objective is to improve the quality of teaching, it would not be unreasonable to use whatever pressures are available to see that these beneficiaries of this program which the taxpayers are providing for that primary purpose should live up to it.

Dr. WATERMAN. This is a very troublesome point which I have heard discussed many times. I think our feeling is that we find practically all of them do go back and it is not very much of a problem. But, to put the requirement in there is not a way that the people like too well, to state that they just have to go back into teaching.

Mr. THOMAS. Let us take a look at your next three programs. I think the committee had some doubt about these three programs. Some of them are new, or relatively new, and they total about $18.3 million.

You have special projects in science education, course content improvement, and science education and personnel studies.

Let us take a look at your big one here.

Special Projects in Science Education

At this point in the record we shall insert pages 230 through 234 of the justifications into the record.

(The pages referred to follow:)

Special Projects in Science Education, $11,300,000

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
Science education for students	$6,535,223	$7,000,000	$7,128,600	+128,600
Science education for teachers	2,380,569	3,671,400	3,671,400	0
Public understanding of science	25,113	500,000	500,000	0
Program total	8,940,905	11,171,400	11,300,000	+128,600

As indicated above, the fiscal year 1961 budget estimate for science education for students is $7,128,600, or $128,600 more than the amount budgeted for this purpose in fiscal year 1960. The amount estimated for science education for teachers ($3,671,400), and the amount requested for public understanding of science ($500,000), remain the same for fiscal year 1961 as that budgeted for these programs in fiscal year 1960.

Included in this group of activities are (1) experimental approaches to the problems of science education which are undergoing further testing and development and (2) new and promising approaches, some of which have been proposed to the Foundation and others, as yet unidentified specifically, which experience shows will be proposed. Many of these approaches are not properly encompassed within the other programs of the Foundation. In the strict sense all of these are developmental activities and the funds allocated to them represent investment capital—investment which has yielded rich dividends in the past. These are science educational activities which are watched with great interest by the entire scientific and educational community.

To the extent that the requested funds will be used in the further development of projects already underway or planned, their use is predictable. To the extent that a relatively small fraction of these funds will be used to support quite new ideas, specific budgets at this time must necessarily represent rough estimates.

A basic technique employed by the Foundation for supporting efforts to achieve better education in the sciences is the acceptance of unsolicited proposals from the academic and scientific communities, the careful review of those proposals, and the support of those judged to hold the greatest promise of success. Over the past 8 years the majority of these proposals have fallen into clearly identifiable categories around which specific programs have been developed. Except for the initial fellowships programs which were specifically authorized by the National Science Foundation Act, nearly all of the Foundation's science education programs have emerged in this way.

Fortunately, the Foundation continues to receive proposals for activities that do not neatly fit into some previously established pattern and program. Each such proposal is given careful review irrespective of its novelty. Often novel proposals are received which so clearly embody excellent and timely ideas that their early support is deemed highly desirable. Thus it is exceedingly important that the Foundation continue to be able to accord full attention to such excellent ideas; this means that there is need for a certain amount of flexibility in utilizing the funds assigned to the special projects category of activities. The general term "Special Projects in Science Education" includes both the new and promising ideas and also those that have been supported experimentally, found

worthy of further support and are being developed—in some cases—to an operational level. It is through this mechanism that the successful special training programs for teachers (the several types of institutes), the curriculum improvement program and others came into existence.

It is not possible to fully predict at this time the number and nature of the new ideas which are sure to reach the Foundation during fiscal year 1961. Hence this component of the special projects in science education activity may be considered in some ways analogous to the Foundation's fellowship programs, where it is possible to specify in advance the broad outlines of each of the several fellowship programs, but not the individuals to be chosen for awards. On the other hand, it is possible, on the basis of (1) past experience and (2) plans for further testing and development of some current activities, to outline the general areas of approach and the funds necessary to support them.

The special projects activities for fiscal year 1961 will center around three general areas: (1) scientific education for students, (2) scientific education for teachers, and (3) public understanding of science. In each case, these include only those activities which are found after appropriate evaluation to be worthy of trial or developmental support—and which are not dealt with elsewhere or in other ways. The following descriptions of the principal kinds of activities in each of these three categories exemplify the mechanisms in use (or soon to be launched). Past experience has shown that this classification scheme embraces virtually all of the proposals likely to be found worthy of initial or continuing support.

Science education for students.—Science training at the secondary school level is accomplished not only through the development of sound curriculums and the training of good secondary school teachers. Students should also be provided with extracurricular opportunities to advance their understanding of and interest in science and technology. Information on the opportunities for careers in science and technology makes it easier for students at this critical age to arrive at better informed and therefore wiser decisions with respect to choice of a future career. Early interest in future career possibilities and requirements provides a powerful motivation for the student to pursue his education with vigor and increased interest. This same information generally disseminated among all students provides part of the foundation for a sound public understanding of science on the part of the future citizens. For the high-ability student with a well-developed interest in science, extracurricular activities play a leading role in maintaining interest and accelerating and intensifying preparation for a career in science and technology.

Through grants, Foundation support is provided for organizations which encourage extracurricular activities such as science clubs and fairs, junior academies of science, summer science activities, and special lectures by visiting scientists. Science clubs and student projects provide opportunities for the science-motivated student to utilize effectively his out of school time in an interesting and productive way. Summer science training programs offered by colleges, universities and research institutions provide useful and stimulating education experiences for the serious and able high school student. They not infrequently augment the limited science teaching facilities of the less well-equipped high school. Visits to secondary schools by distinguished scientists from college and university campuses, research institutions and Government laboratories under the auspices of professional scientific societies effectively augment the education resources of the secondary school in providing career information, advanced science training and guidance to the students in curricular and extracurricular science activities. Such programs have all given evidence of successfully developing a thirst for scientific knowledge and an interest in scientific careers and research among precollege students.

At the undergraduate level there is a real need to identify those students of science and technology who have potential as research workers and teachers in institutions of higher education. With the rapid expansion in scientific research, much of it conducted by the Federal Government or financed through Federal grants or contracts, it is essential that a substantial number of those undergraduates who are intellectually equipped to do so go into the Nation's graduate schools to be trained as research workers. The projected increase in college population in future years makes it necessary that many qualified students of science, mathematics and engineering become interested in equipping themselves for admission to the graduate schools and preparation as college-level teachers. An essential element in the preparation of a research worker or college faculty member is independent study and research. Undergraduate

students of high ability enrolled in the Nation's large universities can begin their training for scholarly careers through independent study under the direction of the institution's leading scholars and through participation in the research programs of these outstanding scientists. Many of the undergraduate students with high potential for careers in research and college teaching are enrolled in colleges, schools and universities where primary emphasis is on undergraduate teaching rather than on large-scale research. These students, too, need to be introduced to research and the independent study that is essential to scholarly development. At these institutions research programs can often be developed by competent faculty members for the specific purpose of providing training in the methods of research. In the case of those institutions that are primarily concerned with undergraduate instruction, visiting scientists from the Nation's leading research installations augment the research training available on the local campus. The Foundation-supported undergraduate science education programs are designed to make it possible for colleges and universities to encourage and permit qualified undergraduates to participate in the type of valuable research programs described above.

Science education for teachers.—In addition to the well established teacher training programs in science provided through the conventional teacher institute and fellowship program, there is a continuing need for special programs designed to develop and test new ideas in science teacher education. These include programs for training teachers to instruct in special fields of science where manpower shortages are acute; institutes for teachers designed to develop advanced science courses for high ability students; research participation programs that make it possible for science teachers to include research training in the curricula of high ability undergraduate students; and one-of-a-kind conferences and symposia devoted to the solution of important problems in science education or undertaken for the purpose of instructing teachers in new developments in science resulting from recent research. Such teacher improvement programs are part of the Foundation's major effort to improve science education through providing additional subject matter background and experience for teachers of science, mathematics, and engineering.

In addition to utilizing the science resources of the Nation, the Foundation-supported program for the development of science teachers undertakes, where appropriate, to utilize the science resources of other nations to advance science education in the United States. This includes providing for studies of foreign science education systems, textbooks, and course and curriculum content. Distinguished foreign scientists are added to the faculties of teacher institutes and are included in the visiting scientists programs of the American professional scientific societies. Where it is advantageous to the advancement of American science education, distinguished American scientists and science teachers are permitted to engage in cooperative educational activities with their colleagues in other countries. Furthermore, American colleges and universities are able to invite eminent foreign scholars to participate in educational programs in this country with the objective of improving the quality of instruction in mathematics and science. In conjunction with these activities the Foundation is requested to give an ever-increasing amount of attention to carrying out its roles as a focal point for this Nation's cooperative efforts with other nations in the general area of science education and science manpower studies.

Public understanding of science.—Progress in science is directly related to the degree of understanding and support that the general public has for the basic concepts and methods of science. The primary objectives of this Foundation's program in public understanding of science is to improve communications between the scientific community and the lay public. Advances in science and technology develop with such rapidity that it becomes increasingly difficult for the citizen not directly involved to understand the meaning of individual scientific developments and to assess properly their importance in terms of his own and the Nation's welfare. Dissemination of information of public interest is the role of the mass media—newspapers, magazines, radio, television, etc. If these media are to meet their responsibility in providing understandable yet accurate information to the public in the realm of science and technology, better rapport must be developed and maintained between those who are concerned with the dissemination of news and the scientific community. As science moves ahead on all of its frontiers it becomes increasingly difficult to translate significant breakthroughs in a way that can be easily understood by the general public. The technical and professional language of the scientists and engineer must be translated into the language of the layman without distortion

or needless loss of meaning, accuracy, or precision. To accomplish this, the writer and reporter must have a real understanding of science, and yet he cannot be expected to be trained as a scientist. It is equally essential that the scientist who is the ultimate source of science news be aware of the professional problems of the journalist. Educational programs designed to bring scientists and technologists together with writers and reporters for the purpose of increasing their mutual understanding of the problems of achieving an informed citizenry in the area of science are becoming daily more necessary.

Mr. THOMAS. I have written on two or three of these paragraphs "vague."

Take, for instance, this one on page 231:

It is not possible to fully predict at this time the number and nature of the new ideas which are sure to reach the Foundation during fiscal year 1961. Hence this component of the special projects in science education activities may be considered in some ways analogous to the Foundation's fellowship programs, where it is possible to specify in advance the broad outlines of each of the several fellowship programs, but not the individuals to be chosen for awards. On the other hand, it is possible, on the basis of (1) past experience and (2) plans for further testing and development of some current activities, to outline the general areas of approach and the funds necessary to support them.

That is pretty indefinite; is it not?

On page 232 of the justifications there is some more interesting reading under "Science education for students."

You show an increase of $128,600, for a total of $7,128,600.

Science education for teachers reflects no increase and is in the amount of $3,671,400.

"Public understanding of science" contains a "hog round" figure this year, and last year, of $500,000.

Your justifications state as follows:

Included in this group of activities are: (1) Experimental approaches to the problems of science education which are undergoing further testing and development * * *

That is pretty vague, is it not.

You further state:

New and promising approaches, some of which have been proposed to the Foundation and others, as yet unidentified specifically, which experience shows will be proposed.

How indefinite can you get?

Dr. WATERMAN. This is like research, Mr. Chairman.

Mr. THOMAS. Here is another good, interesting paragraph:

To the extent that the requested funds will be used in the further development of projects already underway or planned, their use is predictable. To the extent that a relatively small fraction of these funds will be used to support quite new ideas, specific budgets at this time must necessarily represent rough estimates.

Under your "Public understanding of science" you have the amount of $500,000.

Please tell us about that program.

Dr. WATERMAN. There has been a great deal of thought given to this, Mr. Chairman. We feel that the people could gain greatly by a better knowledge of what science does and what science is and what basic research is, for example. The questions that are coming up before the people now are sometimes——

Mr. THOMAS. How much have you spent of your $500,000 on this program last year?

Do you have figures on that, Mr. Luton?

Dr. DEES. Mr. Chairman, this is a relatively new program. We have, as I remember, obligated approximately $50,000 of this $500,000 in this fiscal year. We have already in hand, however, a considerable number of proposals that we are screening, and it is our anticipation that most of the money in this area will be obligated.

Mr. THOMAS. Are we not going a little overboard in these three programs to the tune of about $11,300,000?

Could you not spend your money better? You are getting into too much detail and work, and you are getting into the field of the high schools themselves. We are making ourselves liable to the charge that the Federal Government is running around all over the country, sticking its nose into the very grassroots of the field of education.

Here are three programs which will get you in trouble.

Dr. KELLY. May I comment on a few of the very successful parts of this program?

Mr. THOMAS. Surely.

Dr. KELLY. One is the undergraduate research participation program. This is a program directed mostly toward the small college and directed toward giving the students highly desirable research-oriented training.

Mr. THOMAS. You have a dozen programs mixed up here under 3 headings, and certainly 2 or 3 of them are good, but there are about 9 or 10 which you should take another look at and which are highly speculative.

Dr. WATERMAN. I suppose you would call this the research sector of education in the sciences. Here we are able to try out things.

Mr. THOMAS. Doctor, do not use that word "research" as a rug under which will sweep a good many things. It is not a coverall.

Dr. WATERMAN. No; these are where we can try experimental and pilot operations in a small way and see if they are successful, and if they are, perhaps, they can be picked up by the schools.

Mr. THOMAS. Pick out your programs which you think are really the good ones.

What about your "Traveling libraries"?

Dr. WATERMAN. Did you want to speak to this in detail, Dr. Dees?

Mr. THOMAS. Your justifications state as follows:

> The earliest programs conducted by the Foundation in support of secondary school students were those for visiting scientists, traveling science demonstration lectures, and traveling science libraries.
>
> In addition to these programs, Foundation support will also be continued in the areas of education programs of State and local academies of science, summer science training, science clubs and student science projects, science career information, and supplementary secondary science education. Details of each of these eight programs are set forth in the following accounts.

Dr. WATERMAN. There is an interesting one here, too, Mr. Chairman, of helping the local and State academies of science to accomplish things in their own territory. That has been an experimental one which seems to have a good deal of promise.

Mr. YATES. Are these governmental institutions, the State and local academies?

Dr. WATERMAN. No, sir; they are organized by State and usually by the scientists in the State. They may have a State charter, but they are not under the State government.

Mr. THOMAS. Here we have your "Traveling science libraries" wherein you are requesting $250,000. You have three big programs and they all overlap and deal with practically the same subject.

Will you please pick out which are the good ones, and which ones do you really have doubts about? When I say "doubts" I mean they are in the category of experiments?

Dr. DEES. Mr. Chairman, you just told us to pick out the good ones. We have, I suspect, in the last 3 years——

Mr. THOMAS. When I said "good ones" I meant the ones which are tried, true, and tested, and ones which are paying off. The others are still in the experimental stage.

We are giving you the opportunity to put your own appraisal on them.

Dr. KELLY. This is reflected in the budget. Those which have shown less promise are decreasing. The undergraduate research participation program is most successful and most promising, and could be expanded even much more than we have requested here. We have a program for high school students of high ability. This is an experiment we are trying, because under our act we have responsibility for a scholarship program.

Mr. THOMAS. What do you do for those students? How do you contact them? Half of the people in my country have not heard of the program.

Dr. KELLY. The grants are made to colleges and universities and these institutions pick out these students.

Mr. THOMAS. In that regard we want to look at your grants in aid to education. About four or five States get about 40 percent of it. The rest of the States are getting very little. However, we will go into that later.

Dr. KELLY. On the other end of the spectrum, we are decreasing the traveling science libraries because we think we have stimulated the local communities.

Mr. THOMAS. Suppose we cut this $11 million in half, and leave it up to you as to where you are going to spend it?

Dr. KELLY. We could use three times this much money for undergraduate research alone, Mr. Chairman.

Mr. THOMAS. You could use more than that, I imagine.

Mr. JONAS. This is the area in which you are in competition with scientists of tomorrow; is it not?

Dr. KELLY. No, sir.

Mr. JONAS. That is, high school institutes for high school students?

Dr. DEES. If I may say so, Mr. Jonas, we are in competition only because they want us to turn the program over to them. They wanted us to support it, but let them run it.

COURSE CONTENT IMPROVEMENT

Mr. THOMAS. What about your "Course content improvement"?

We shall insert at this point in the record pages 261 to 263 of the justifications.

(The pages referred to follow:)

Course Content Improvement, $6,000,000

Summary—Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
Elementary and junior high schools	$558,910	$500,000	$750,000	+$250,000
Secondary schools	3,519,000	3,000,000	3,000,000	0
Colleges and universities	210,950	1,000,000	1,000,000	0
Subtotal	4,288,860	4,500,000	4,750,000	+250,000
Supplementary teaching aids	1,741,465	1,500,000	1,250,000	−250,000
Program total	6,030,325	6,000,000	6,000,000	0

Budgets for projects supported under this program inevitably vary widely according to scope, specific objectives, and plans adopted to attain those objectives in an effective and efficient manner. The following items are among those which may be included in grants from the National Science Foundation:

1. Stipends, salaries, and consultant fees for scientists and teachers engaged full time or part time in devising courses, instructional materials, or supplementary teaching aids, including trial use in classrooms and subsequent revision.
2. Salaries and wages for secretarial and technical assistance.
3. Support for conferences, writing sessions, and programs for testing new courses and materials.
4. Materials, equipment, and facilities, ranging from office supplies and shop facilities to modest film studios.

Program objectives and needs.—It is characteristic of scientific discovery that each new finding raises new questions and provides new means for attacking old questions. The frontier is an expanding one. As knowledge grows, the need for highly trained people to continue the search and apply the results grows apace. So, too, does the need for all educated men and women to understand the essential core of our accumulated knowledge, the way in which it is gained, and the meaning it has for our individual lives, our society, and our very survival. The corollary is that courses and curricula in mathematics, science, and engineering should continuously keep abreast of scholarly advances. The fact is they have not. Some teachers and certain schools have done a good job. In general, however, mathematics and science courses in elementary and secondary schools, and in many undergraduate colleges, lag a generation or more behind the advance of knowledge. Our Nation cannot afford this lag, the results of which are seriously outdated courses, lack of student interest, and inadequate understanding of the potentialities of scientific achievement.

The purpose of the course content improvement program is to help rectify this situation by encouraging mathematicians, scientists, engineers, teachers, and other specialists to collaborate in constructing new instructional programs and aids for teaching and learning. Such programs will give students access to the essential core of the ever-increasing store of knowledge, will stimulate curiosity and individual intellectual capabilities, will lead adequate numbers to embark upon careers in science and technology, and will produce a scientifically literate citizenry.

The need has recently been underscored by scientists, educators, and laymen. The President's Science Advisory Committee, for example, makes this statement:

"The quality and content of the curriculum is central in education. At every level in the school, college, and graduate school the curricular offerings must provide the basic educational materials required of all students, plus the broad selection of opportunities appropriate to the student body involved * * *. We urge the scientists and scholars of the country to establish more intimate contact with experienced teachers at all levels, so the curricula and the teaching and learning aids in schools, colleges, and universities may take account of the new facts and the new points of view that scientific progress has revealed * * *. The content of courses in mathematical and scientific fields at both the secondary and undergraduate college level does not adequately recognize scholarly advances in these fields. We recommend that present efforts be aggressively pursued and

substantially expanded in bringing together leading scientists, scholars, and teachers in these various subject-matter fields to seek—

"1. To bring the course content in each subject at each level into line with the most modern scholarly research in its field, consonant with the level of instruction.

"2. To outline, write, publish, and revise the necessary textbooks and auxiliary reading materials to achieve the above objectives.

"3. To develop and supply adequate teaching and learning aids of all appropriate kinds, including motion pictures, television, tape recordings, slides, and other audiovisual materials designed to aid the student in understanding the subject more thoroughly, and especially to relieve the teacher of unnecessary burdens of preparation and instruction, and to enable the outstanding teacher to reach a much larger number of students.

"4. To develop and supply laboratory equipment and materials for science courses together with the necessary manuals and reading materials to make the laboratory and fieldwork a far more meaningful, useful, and exciting aid to student and teacher ('Education for the Age of Science,' 1959, pp. 31–32)."

Type and scope of program.—By fiscal year 1959, the Foundation's course content improvement program had become a major program, following the success of earlier, relatively modest experiments. The first major effort to focus the talents of a large group of scientists and teachers upon a course content study was initiated during fiscal year 1957 in a project to design a new high-school physics course. This massive undertaking is still underway but nearing completion. The new course, including a textbook, teachers' manual, laboratory guide, kit of apparatus, films, supplementary readings, and examinations, will be ready for general use in the fall of 1960. By that time the development will have required 4 years, the arduous labors of some of the Nation's top physicists and teachers, and an investment of several million dollars. It is of interest to point out that in addition to money the Foundation has put into this program (approximately $4.1 million), the Ford Foundation, the Alfred P. Sloan Foundation, and the Merck Co. Foundation contributed an additional $754,000. This illustrates the magnitude of the task. The cost, however, is but a very small fraction of the approximately $60 billion the United States will have spent on education during those 4 years. The funds have been well invested, for more than 12,000 students have already had access to this improved course and hundreds of thousands more will have the benefit of the course during the next few years.

During fiscal year 1959 the National Science Foundation course content improvement program was expanded, with special emphasis being placed on courses in secondary schools and in undergraduate colleges. Continuation of the program during fiscal year 1960 will see projects begun or well underway in mathematics, astronomy, geology, meteorology, physics, chemistry, the life sciences, psychology, anthropology, engineering, and other disciplines at all three educational levels: elementary, secondary, and college. The work thus begun requires continued support during fiscal year 1961 if these many projects are to be successfully developed and implemented.

Mr. THOMAS. Your request for 1961 is in the amount of $6 million, the same amount as you had last year.

What are you doing in that field? Can you put your finger on some concrete, good results?

Dr. DEES. Mr. Chairman, this is an area where we have a really new, burgeoning and already-proven set of ideas coming forward.

Mr. THOMAS. You have four big programs. You have the elementary and junior high schools, where you are requesting the sum of $750,000; this shows an increase of $250,000 over 1960.

Then you have your secondary schools wherein you are requesting $3 million, the same amount as last year; you have your colleges and universities wherein you are requesting the same amount as last year, $1 million; and then you have supplementary teaching aids wherein you are requesting $1.25 million, which represents a decrease of $250,000.

Dr. KELLY. This is the program we discussed a little bit yesterday, and Dr. Stratton from MIT spoke so highly of. The program, I think, is one that we can be most proud of; this has resulted in the top leaders of science, Nobel Prize winners in some cases, working with high school teachers on the course content material for the high schools.

Mr. THOMAS. Let me read your own language into the record. It is very interesting language:

> It is characteristic of scientific discovery that each new finding raises new questions and provides new means for attacking old problems. The frontier is an expanding one. As knowledge grows, the need for highly trained people to continue to search and apply the results grows apace. So, too, does the need for all educated men and women to understand the essential core of our accumulating knowledge, the way in which it is gained, and the meaning it has for our individual lives, our society and our very survival.

You further state as follows:

> The purpose of the course content improvement program is to help rectify this situation by encouraging mathematicians, scientists, engineers, teachers, and other specialists to collaborate in constructing new instructional programs and aids for teaching and learning.

Just what have you done for that $6 million this year, and what will you do for it next year?

Put your finger on something definite. We can read these nice words and we all like to hear them.

Dr. DEES. This year, Mr. Chairman, we are supporting on a continuing basis the work of the Physical Science Study Committee which was begun 3 years ago, as Dr. Kelly pointed out, under the suspices of some of the outstanding scientists of the country.

This program is approaching completion and will be completed within the next 12 months. Already well over 600 schools in the country are using the materials.

Mr. THOMAS. How many of your people are engaged in that study, and when will they have it completed, and what are you paying them on an annual basis?

Those people are going to rewrite your textbooks? That ought to be worth your money.

Dr. DEES. Yes, sir; this is exactly what is happening, plus a good many other things. They are not only rewriting the textbooks in physics, but they are also providing teacher-training devices.

Mr. THOMAS. What did it cost you for 1960?

Dr. DEES. The 1960 grant that we are about to make will probably total $350,000.

Mr. THOMAS. What is the title of the group?

Dr. DEES. The Physical Science Study Committee.

Mr. THOMAS. What are they rewriting? What textbooks?

Dr. DEES. The high school physics program. It is not just the textbook, but also all of the ancillary materials.

Mr. THOMAS. Where is the rest of the money?

Dr. DEES. In this year we are supporting also two chemistry groups, each approaching the problem from a somewhat different direction, for the high school chemistry course.

The Chemical Bond Approach Committee is one.

Mr. THOMAS. How much are you spending with them?

Dr. DEES. We have made two grants to the chemical bond approach group, and my recollection is that these would total about $340,000.

Mr. THOMAS. What will you complete the fiscal year 1960 with? How much money out of your $6 million for this program will you have left?

Dr. DEES. We have already proposals on hand—and several of them have been essentially fully evaluated—which indicates that we will undoubtedly have need for more than the $6 million and, therefore, grants totaling $6 million would cover only part of the needs in this program.

Mr. THOMAS. Please detail how you are spending the $6 million, with whom, and for what purpose. You have mentioned two study groups, one in physics, and one in chemistry.

Dr. DEES. The second program in high school chemistry is under the leadership of Dr. Glenn Seaborg, a Nobel laureate and president of the University of California, and is expected to be funded at approximately $1 million.

Mr. THOMAS. That is $2 million.

What about the rest of it?

Dr. DEES. The expectation also is that we will support several projects—in addition to those we have already made grants for—in the field of college science course improvement. We are supporting a series of conferences by 60 of the outstanding research workers and teachers in college level physics throughout the country, to determine the direction in which improvement in college physics teaching can most profitably go.

Mr. THOMAS. You have physics and chemistry and paid $600,000 for it.

Dr. DEES. Biology and mathematics are also covered in these grants. We have made a $1.75 million grant this year to the School Mathematics Study Group, a group which includes something like 100 of the outstanding mathematicians in the country, working on a number of campuses with respect to the improvement of mathematics materials at grades 7 through 12.

Mr. THOMAS. Doctor, will you put it down very clearly here the name of the study groups and what they are going to do, the dollar amount, and insert it in the record?

Dr. DEES. Yes, sir.

(The information requested follows:)

Total support for major secondary-school curriculum studies through Mar. 7, 1960

	Nov. 27, 1956, through Mar. 7, 1960
Physical Science Study Committee	$4,113,440
School mathematics study group	3,100,000
Biological sciences curriculum study	738,200
Chemical bond approach project	367,125
Chemical education materials study	11,500
Total	8,330,265

Mr. THOMAS. Does it all total up to $6 million?

Dr. DEES. For fiscal year 1960 we anticipate that it will, at least $6 million, Mr. Chairman. We still have 4 months left in this year, and we have not made nearly all of the grants which will be made.

Mr. THOMAS. This is a recurring item. You started it in 1959 and you had an appropriation in 1960 and you now want one in 1961.

How long is it going to take to rewrite these textbooks? In brief, this is a rewriting job; is it not? In my opinion it is the best part of your program which totals $18 million or $20 million.

We are trying to help you to justify it.

Dr. KELLY. We have experience as to the probable cost of each one of the other studies. The total for the Physical Science Study Committee was approximately $5 million.

Mr. THOMAS. You have already gotten $6 million for it in 1959 and 1960.

Dr. KELLY. But we have three other fields plus the college and plus the elementary school level.

Mr. THOMAS. How long is this program going to continue before it is completed?

Dr. WATERMAN. The physical-science study is beginning to wind up. The others are only beginning. However, we expect the physics one will be completed before long.

Mr. THOMAS. You estimate a $5 million cost. You have had $12 million already appropriated for this purpose.

Dr. DEES. $5 million for physics at the high-school level only, Mr. Chairman.

Mr. THOMAS. What is it going to cost at the high-school level to complete your program for physics, chemistry, math, and all the rest?

Dr. WATERMAN. Chemistry is just beginning, and biology is underway.

Mr. THOMAS. Please give us a preview, and how long it is going to take to do the job.

Dr. DEES. It is very likely that at the senior-high-school level, that is, grades 9 through 12, that it will take on the order of $20 million to $25 million to do the same quality of job across the board in biology, physics, math, and chemistry that is already being accomplished in the physics area.

Mr. THOMAS. $25 million for one subject?

Dr. DEES. For these four subjects.

Mr. THOMAS. Physics, chemistry, biology, and math?

Dr. DEES. All of the high-school sciences and mathematics.

Mr. THOMAS. How much have you had appropriated for that purpose to date?

Dr. DEES. Of the order of $13 million, because prior to 1959 we had only a very small amount for this.

Mr. THOMAS. What about the college-level problem? Are you going to attack the textbook problem at the college level also in the same fields?

Dr. DEES. Yes; but it is very likely that this will be approached in a necessarily different way because whereas it is possible to prepare—

Mr. THOMAS. Are you spending any of your $12 million that you have in hand now for fiscal 1959 and 1960 for college-work improvement?

Dr. DEES. Yes, sir.

Mr. THOMAS. They are going hand in hand—high school and college?

Dr. DEES. Yes, sir.

Mr. THOMAS. What will your course improvement at the college level in textbooks cost? You gave a figure of $25 million for the high schools. What will the college work cost?

Dr. DEES. The college problem, as you know, is very much more complex because it includes other fields as, for example, engineering.

Mr. THOMAS. Doctor, we understand that, or at least we can take your word for it.

What about the dollar mark?

Dr. DEES. Frankly, Mr. Chairman, we do not at this point in time have a firm figure, because this is an area—the college level—that we are only beginning to tackle in a substantive or substantial way. If you wish an educated guess, the cost would be something of the order of $30 million to $40 million over a period of a number of years, meaning 4 or 5 years, more or less.

Dr. WATERMAN. I would like to say, Mr. Chairman, that it is the opinion of most teachers and educators I have talked to that this is a very impressive program indeed. This will be stimulating especially to teachers because it brings the sciences up to date in a manner that they can teach.

Mr. THOMAS. How did you arrive at your figure of $300,000 which you are paying for this particular group of people who are rewriting the textbook in physics?

How did you arrive at that?

Dr. DEES. On the basis of a very detailed budget that they have submitted to us for the various components of the program that are going forward.

Mr. THOMAS. Do you mind showing that to the committee?

Dr. DEES. Not at all. We do not have it with us, but we can insert it in the record at this point.

(The information follows:)

NATIONAL SCIENCE FOUNDATION SUPPORT FOR THE PHYSICAL SCIENCE STUDY COMMITTEE

TABLE 1.—*Dates and amounts of grants to the Massachusetts Institute of Technology for support of the work of the Physical Science Study Committee*

Date granted:	*Amount*
Nov. 27, 1956	$303,000
June 28, 1957	142,000
Aug. 14, 1957	100,000
Nov. 25, 1957	200,000
May 19, 1958	200,000
Sept. 23, 1958	1,768,440
Mar. 26, 1959	1,400,000
Total	4,113,440

TABLE 2.—*Total expenditures of the Physical Science Study Committee under NSF grants, inception to Jan. 31, 1960, by expense category and by program*

Category:	*Total expended Oct. 1, 1956, to Jan. 31, 1960*
Salaries and wages	$1,233,117.06
Consultants	612,713.43
Travel	180,938.08
Materials and services	1,400,101.07
Overhead	[1] 182,675.89
Total	3,609,545.53

[1] Indirect costs charged as separate item only during the period Oct. 1, 1956, to Dec. 30, 1958. After the latter date Educational Services, Inc., assumed administrative responsibility under the Massachusetts Institute of Technology.

Program:	
Textbook, laboratory guide and apparatus, examinations, monographs	$1,063,607.29
Teacher's guide and feedback from trial schools	319,211.32
Film program	1,289,115.37
Distribution of materials	404,848.70
Administration	552,762.85
Total	3,609,545.53
Total NSF grant	4,113,440.00
Total expenditures to January 31, 1960	3,609,545.53
Funds available for operations, remainder of fiscal year 1960	503,894.53

Physical Science Study Committee

Development and distribution of instructional materials

Objectives and materials

The purpose of the Physical Science Study Committee has been to create a complete new course in physics for secondary schools. The Committee has stated its aims thus: (1) to plan a course of study in which the major developments of physics, up to the present time, are presented in a logical and integrated whole; (2) to present physics as and intellectual and cultural purusit which is a part of present-day human activity and achievement; and (3) to assist physics teachers, by means of various teaching aids, to carry out the proposed program.

To this end the Committee is developing a closely integrated set of teaching materials, designed to use every type of learning experience in enabling students to gain as thorough an understanding of the subject as possible in the time available and at the secondary school level. These materials include:

1. A textbook, "Physics," now appearing as a revised preliminary edition issued in four volumes.
2. A laboratory guide for student experiments, also in four parts.
3. A kit of specially developed apparatus for student experiments.
4. Some 60 motion pictures averaging 20 minutes in length in which leading physicists present demonstrations and discussions, thus providing experiments not feasible in most schools.
5. A special series of 12 examination.
6. Paperback monographs written by leading physicists to cover a wide range of special topics; some 70 are planned.
7. A teacher's guide containing background material and suggestions on teaching the course.

School trial

In order to make the course as sound and effective as possible, extensive trial in schools and repeated revision of early versions of materials has been necessary. School trials and use have been as follows:

School year	Number of schools	Number of students	Comment
1957–58	8	300	1st test group; all materials supplied by Committee.
1958–59	270	12,000	2d test group; all materials supplied by the Committee under the management of Educational Services, Inc. (ESI).
1959–60	600	24,000	Test group limited to about 50 schools, for which the Committee provides materials. All others purchase the materials from ESI at cost, except for films. The films are still in a developmental phase and all prints are owned by the Committee. Each school receives an average of 12 films for trial purposes.

Cost of materials for test schools, fiscal year 1958 (school year 1958–59)

Number of schools	270
Number of students	12,000
Total cost	$180,000
Cost per student	$15
Total distribution costs, fiscal year 1959	$195,462.72

Includes materials for test schools, materials for grantors and other agencies, personnel involved in project, and project developmental work. Copies of the text were also sold to interested individuals at cost.

PRODUCTION AND DISTRIBUTION, 1960–61 SCHOOL YEAR AND SUBSEQUENTLY

Beginning in the fall of 1960 materials will become available for purchase by all schools wishing to use them.

Materials will then be puroduced and distributed by commercial concerns under contract with Educational Services, Inc. All qualified and interested concerns were given opportunities to bid on the production contracts, which were awarded to firms providing terms most satisfactory to the Physical Science Study Committee, including continuing supervision of content by the committee and low costs for schools. Mass production and the fact that textbooks, laboratory guides, films and some apparatus can be used for several years are expected to bring the cost per pupil much below the average cost for students in the test schools during the developmental period.

Educational Services, Inc., is a nonprofit organization founded in September 1958 to administer the secondary school physics project of the Physical Science Study Committee and to assist their research and development projects in the field of education. Royalties from sales of materials for the physics course will be used to revise and improve materials as this becomes desirable.

Production arrangements are as follows:

Textbook, laboratory guide, teachers' guide: D. C. Heath & Co.
Laboratory apparatus: Macalester Bicknell Co.
Science study series (monographs): Doubleday & Co., Inc. (trade edition); Wesleyan University Press (school edition).
Films: Under negotiation.

Mr. THOMAS. Do you have any idea what the elements of cost are?

Dr. DEES. There are salary costs, which on the basis of past experience I would say would represent, roughly, 40 percent. Then there will be travel costs at a small percentage, say, of 5 percent.

This particular group is involved in attempting at this point to revise their own product on the basis of what they refer to as "feedback" from the schools.

They are already using this material in a number of schools and they are getting critiques from the teachers using it, and it is possible, therefore, for them to evaluate certain sections of the material and strengthen it.

Mr. THOMAS. Gentlemen, if this business is as important as we all think it is, it should not drag on over a period of 10 or 15 years and be that indefinite.

Let us get on top of it and see if we cannot get it behind us.

If it is as valuable as we think it is, why waste all this time dragging it out?

Dr. WATERMAN. I think, Dr. Dees is speaking about the overall problem. We are trying to complete as rapidly as possible the secondary school situation and then the college work will be done in the next phase.

That was really what I think he had in mind when he referred to dragging it out.

Mr. THOMAS. That word "drag" is not illy used here. We have had this program going for 2 years.

Dr. KELLY. There must be a time lag because of the difference in teaching at the high school level, which is necessarily going to affect what is being taught in the college and also will influence what will happen in the elementary school.

Mr. THOMAS. In other words, you are going to have to test out how good your high school book is before you write your college book?

Dr. KELLY. Partly that, but also to determine what subject matter can be put down from the college level to the high school level.

Mr. JONAS. Do I understand that you put $4.1 million in this physics textbook?

Dr. WATERMAN. Is that the correct figure?

Dr. KELLY. Not just in the textbook. I think we should emphasize there is a textbook, teachers' manuals, laboratory manuals, and laboratory equipment, as well as films.

Dr. WATERMAN. Yes; motion pictures.

Mr. JONAS. In addition to that $4.1 million, the Ford Foundation, the Sloan Foundation, and the Merck Foundation put up $754,000?

Dr. DEES. Yes, sir.

Mr. JONAS. Did those funds finance the development of the course?

Dr. DEES. The $350,000 that I referred to a few minutes ago, Mr. Jonas, would be added to this figure.

Mr. JONAS. That would total, then, about $5.5 million.

Who has the copyright on the material?

Dr. DEES. At the moment the Physical Science Study Committee holds the copyright, with the proviso that the National Science Foundation at all stages has the right to determine disposition and the Government has a nonexclusive royalty-free license to use this material in any way.

Mr. JONAS. Who makes the profit on publishing the text material?

Dr. DEES. There was a series of bids from the various publishing houses to the Physical Science Study Committee in determining who would publish the basic textbook, which is to be published in the next 3 or 4 months. D. C. Heath & Co. will publish the book and the royalties from the sales will revert to the nonprofit group, Educational Services, Inc. (which was set up more or less specifically for this purpose), and the disposition of these royalties is to be determined by the Foundation in consultation with ESI.

Mr. YATES. Why should not that money go to the Government?

Dr. DEES. This is one of the possibilities. The point is that, although this is an important contribution to high school physics, there will not be large moneys resulting from the royalties. There will be the need for continual revision of this material, another of the possibilities is that—rather than continuing to seek separate appropriations for that kind of revision—if the royalties are adequate, they could be used for this purpose.

Mr. JONAS. How many of these textbooks are in use now?

Dr. DEES. Some 600 schools are now using the preliminary version of the physics text. It has not been published in hardback form.

Mr. JONAS. You say at page 263 of the justifications that 12,000 students have already used it.

Dr. DEES. That was true last year when the text was in preliminary form.

Mr. JONAS. What has been the profit so far?

Dr. DEES. Not any.

Mr. JONAS. Where has it gone?

Dr. DEES. There has been no profit.

Mr. JONAS. Well, these 12,000 students had to buy the books; did they not?

Dr. DEES. These were furnished from this grant as a part of the test of the material.

Mr. JONAS. It was a free test, and they did not buy the books?

Dr. DEES. No, sir.

Dr. WATERMAN. We had to try it out, and this is the way we did it.

Mr. JONAS. What was the total cost of the 12,000 books which you published? Give us a breakdown as to what it cost. Frankly, I do not see why you would have to try it out. You are not going to let the students pick out the flaws in it.

Dr. WATERMAN. This is quite a radical move, and therefore we have to find out whether the teachers could handle it successfully and whether the students could grasp it. Therefore, we felt it was quite necessary to do this, especially because some Nobel Prize winners were involved in selecting the material, and we wanted to be sure this was something which could be assimilated by the students.

Mr. JONAS. If we are going to finance 90 percent of the cost of preparing this material, we should be sure that some individual is not going to profit by it.

Dr. KELLY. We are concerned about this, too, and we are concerned that it be as freely available as possible at the cheapest price possible.

Mr. YATES. What was the total cost of the physics book?

Mr. JONAS. $5.5 million. That figure is made up of $4.1 million, plus $754,000.

Dr. DEES. Let us please remember that this is not just the physics textbook. This includes something like $2 million for the preparation of a completely new series of physics films—a series of a type which has never existed before, made up of films which augment instruction in physics in a totally new way.

Mr. YATES. Is not this part of the textbook?

Dr. DEES. Yes, sir, in a sense; we may have here simply a semantic difficulty.

Dr. KELLY. This is textual material.

Mr. JONAS. The students will not pay for the use of the films?

Will you give these films to the teachers?

Dr. DEES. A company has already been found, again on the basis of bids, to make these films available to schools on a rental or purchase basis.

Dr. KELLY. And, also, in the same way, the laboratory equipment which is going to be developed and which has been developed, will be available on the same basis: Sale by a central distributor.

Dr. DEES. The $5 million cost of this effort covers preparation and testing of the text itself, the laboratory manuals, the teachers' manuals, the films, the special laboratory equipment—largely equipment that can be made locally.

Mr. YATES. What did the test show? You had 12,000 students take the test in order to see whether the teachers could grasp it, and whether the students could grasp it.

Who did the testing?

Dr. KELLY. The students were tested by the teachers themselves, and we had comments which were fed back to the Physical Science Study Committee.

Mr. YATES. What was the result?

Dr. KELLY. The test or trial showed that the new materials were very stimulating to the bright student; although the PSSC leaders were initially worried about the results of this new approach on the

more mediocre students in comparison to the usual teaching methods it turned out that the mediocre students in many cases performed more satisfactorily by this approach than under the old.

Mr. BOLAND. Where were these 12,000 students? Was this a cross section of the country?

Dr. DEES. They were in 300 schools all over the country during the 1958–59 school year.

Mr. BOLAND. And the test showed that they actually grasped it quicker and that the revised standard text is probably the answer to the teaching of physics then. This is actually a standard text you are developing to be used by the secondary schools of America.

Dr. DEES. When they wish to choose it.

Dr. WATERMAN. We are just offering it as material.

Mr. BOLAND. You are trying to give them the best possible text for the teaching of a very difficult subject?

Mr. THOMAS. The boards of education of the States take their own textbooks. What are these various State boards of education doing?

Dr. DEES. We might comment, Mr. Chairman, that the education officials in the State of Florida are so very much concerned about their problems, and have been so favorably impressed by this program, they are planning to put the PSSC physics course in all of the Florida schools.

Mr. BOLAND. They will buy their textbooks?

Dr. DEES. Yes, sir.

Dr. KELLY. We talked to the State supervisors of education and discussed this program with them. They are very happy to have some guidance in this.

Mr. YATES. What has been your reaction in other States?

Dr. DEES. Very good.

Mr. YATES. With reference to the 12,000 students you said the very bright were able to grasp it and even it made some impact on the mediocre.

Dr. KELLY. Yes, sir; they learned more physics.

Mr. YATES. What portion of the 12,000 were considered to be the bright ones?

Dr. KELLY. They are chosen so they would be normal classes.

Mr. YATES. I wonder how many of the 12,000 were able to grasp it?

Dr. WATERMAN. I think the point to be considered here——

Mr. YATES. Was it a majority?

Dr. WATERMAN. Yes, sir; by far the majority.

Dr. DEES. One of the very best teachers that we have found in this kind of study made this comment at the recent Association of Physics Teachers' meeting in New York—that he would "want" to use this material if he had a highly selected group of students, but if he had a mediocre group of students, he said he would "insist on using" it, now that he has had experience with it.

Mr. YATES. How does the cost of this compare with the usual textbook that is being used?

Dr. DEES. So far as the textbook is concerned?

Mr. YATES. I mean the text and the film. I do not know whether you are drawing a distinction.

Dr. WATERMAN. The text is the big item.

Dr. DEES. I was just talking about the text.

Mr. JONAS. As I understand what you have said, the visual material is as important a part of the course as the text?

Dr. DEES. It will probably be somewhat more expensive, Mr. Yates, than just using a traditional textbook, and using whatever they may have around the laboratory for laboratory materials. On the other hand, every effort is being made to hold the cost down so that a maximum number of schools can afford it.

Dr. WATERMAN. These new experiments have been designed so that the cost will be nominal, say 50 cents or a dollar for an experiment with homemade materials.

SCIENCE EDUCATION AND PERSONNEL STUDIES

Mr. THOMAS. Let us put at this point in the record page 277 of the justifications, page 278 and page 279.

(The pages referred to follow:)

SCIENCE EDUCATION AND PERSONNEL STUDIES, $1,000,000

SUMMARY

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
National register	$388,876	$400,000	$440,000	+$40,000
Manpower studies	391,409	455,917	460,000	+4,083
Manpower research	0	100,000	100,000	0
Program total	780,285	955,917	1,000,000	+44,083

The science education and personnel studies program is intended to keep the Foundation and the Nation informed on the facts and figures of our scientific manpower situation. As the House Science and Astronautics Committee observed, in commenting on this program:

"* * * with the space-atomic age upon us and with the need for scientific manpower growing daily, the need for a superior manpower tabulation is likewise accelerating rapidly. It must also be kept in mind that America's stature in the international community is becoming increasingly dependent upon her scientists, engineers, and technicians. Knowing who they are, where they are, and what they can do is thus becoming crucial" and "* * * the world situation today makes an effective tabulation of scientific manpower more critical than at any time in the history of the country * * *."

As the above table indicates, the fiscal year 1961 science education and personnel studies budget request of $1 million is $44,000 or approximately 5 percent above the fiscal year 1960 program. The moderate increase requested would be mainly applied to the National Register program. Additional funds are needed to permit preliminary collection activities in new emerging scientific fields and to expand data collection efforts in view of the growing numbers of scientists to be registered.

The program consists of three major activities: the National Register of Scientific and Technical Personnel, manpower studies, and manpower research, and has the assigned responsibility—

1. To maintain the National Register of Scientific and Technical Personnel so that individuals with specialized scientific and technical skills may be identified, located, and placed in priority assignments if national emergency conditions require it;

2. To provide data regarding the supply, utilization, characteristics, training, fields of specialization, and demand for scientific and technical personnel so that in the development of its programs the Foundation may consider the relevant factors of scientific personnel resources;

3. To provide a central clearinghouse for scientific manpower information so that other Government agencies, professional societies, private organizations, and other organizations concerned with scientific and technical personnel may have access to information required in administering their programs; and

4. To undertake a program of research in order to sharpen and improve methods of measuring the demand, supply, and characteristics of scientific personnel, and to develop a better understanding of the institutional framework in which scientists and engineers are employed.

NATIONAL REGISTER OF SCIENTIFIC AND TECHNICAL PERSONNEL, $440,000

Obligations

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961
Registration of scientists and engineers	$253,876	$260,000	$320,000
Operation of register records center	135,000	140,000	120,000
Program total	388,876	400,000	440,000

The National Register of Scientific and Technical Personnel maintains records on the location, training, and scientific specializations of selected scientists and engineers. Individual scientists provide this information to their professional societies which, in turn, pass it along to the register's records center, which is maintained on a contract basis by North Carolina State College at Raleigh, N.C. The register data in the aggregate provide a unique source of information on the supply and characteristics of the scientific population. At the same time, the register is designed to provide a mechanism for the prompt location of individual scientists with highly specialized qualifications when needed for scientific work in the national interest. The register is the only comprehensive program for registration of scientific personnel.

The distribution of the $440,000 required for register program operations for fiscal year 1961 is estimated by major categories as follows:

Registration of scientists and engineers		$320,000
Data collection by scientific societies	$275,000	
Extension to new scientific fields	35,000	
National Research Council operation	10,000	
Operation of register records center		120,000
North Carolina State College operation	$110,000	
Special analyses and listings	10,000	
Total		440,000

Mr. THOMAS. Now, we are back to the Science Foundation. This involves science education and personnel studies.

You break your request down as $440,000 for the national register, which represents a $40,000 increase: "Manpower studies, $460,000," and "Manpower research, $100,000." Your total is $1 million as against $955,917 last year.

We are all familiar with this. What good is it doing?

Dr. WATERMAN. Mr. Chairman, I had something which I thought the committee would be interested in interpolating before taking up this new subject.

Mr. THOMAS. All right.

Dr. WATERMAN. The question was what are the States receiving in the way of funds for this item. In fiscal year 1959 Illinois received for institutes $1,028,130, and for other personnel education received $323,630. Massachusetts received for institutes $1,124,445, and other scientific manpower efforts, $3,608,237. This is the course content largely.

North Carolina received for institutes $1,066,360.

Mr. THOMAS. That information is not in the justifications?

Dr. WATERMAN. No, sir. This is in response to a question a while ago.

Mr. THOMAS. I was going to ask you where it was.

Dr. WATERMAN. Texas received over $1.5 million for institutes and for other manpower grants, $227,090.

Mr. THOMAS. I will ask you for a complete record by States on that.

Set it out by contract, and by institution, and by States for science and we are going to ask for the same thing for manpower.

Dr. WATERMAN. Mr. Chairman, the information requested is all covered in the document entitled "Grants Awarded by the NSF in Support of Science and in Support of Scientific Manpower to Universities and Other Nonprofit Institutions During Fiscal Year 1959" which has been previously inserted in the record.

Mr. THOMAS. You state at page 277 of the justifications as follows:

> The science education and personnel studies program is intended to keep the Foundation and the Nation informed on the "facts and figures" of our scientific manpower situation. As the House Science and Astronautics Committee observed, in commenting on this program:
>
> "With the space-atomic age upon us, and with the need for scientific manpower growing daily, the need for a superior manpower tabulation is likewise accelerating rapidly."

You had been carrying this program on before we had this new space business, and before we had sputnik: is that true?

Dr. WATERMAN. This is an item in our act, and we are required to keep this register.

Mr. THOMAS. What good are you receiving for the expenditure of this $1 million. How are you keeping the record? How many scientists do you have and where are they located, and so forth and so on?

Is not this about $1 million which you could save some place else?

Your justifications state as follows:

> Nine major professional societies—and through them some 200 additional specialized societies—are now cooperating with the Foundation in the registration of scientists and engineers.

In other words, you are subsidizing all these chapters here of these great scientific and engineering institutions who are going to do something which they would normally do anyway?

I have reference to the American Institute of Architects, the American Institute of Electrical Engineers, or whatever it is. How many of them are there? You say there are nine major professional groups. Which are they?

At page 281 of the justifications you state the following:

> The availability of a concentration of highly trained scientific staff in the Raleigh-Durham-Chapel Hill area was an important factor in selecting North Carolina State College to operate the register records center.

Do you only have one center?

Dr. WATERMAN. Yes, sir; for this purpose.

Mr. THOMAS. You further state as follows:

The National Academy of Sciences—National Research Council maintains the Register of Earned Doctorates which covers doctorates awarded by American universities.

You have set up here at this university, about which there is no question that it is an able one, this center. Is this for Dr. Gross' school?

Dr. WATERMAN. No, sir; he is at Duke.

I have the institutions here, Mr. Chairman.

Mr. THOMAS. Name them.

Dr. WATERMAN. The American Institute of Biological Sciences, the Federation of American Societies for Experimental Biology, the American Geological Institute, the American Institute of Physics, the American Meteorological Society, the American Psychological Association, the American Mathematical Society, the American Chemical Society, and the Engineers Joint Council.

Mr. THOMAS. How much of this goes to governmental agencies?

I looked over here and studied your charts with reference to this item of aid to science. You are subsidizing at least six or eight governmental bureaus and are transferring your money to them.

How many in this figure are there?

Dr. WATERMAN. None at the present time. Negotiations are being conducted with the U.S. Civil Service Commission to increase the scope of the register to include Government scientists and engineers.

Mr. THOMAS. What are you giving the Civil Service Commission? Is that figure $5,000?

Dr. WATERMAN. No funds are transferred for the registration of Government scientists and engineers. The Commission is the logical place to find those. The societies do not normally do this, Mr. Chairman. They have their normal membership. The register is intended to list all qualified scientists.

Mr. THOMAS. Why is it necessary to have a dog tag on each one of them if they are so important, and after you have spent money training him and educating him? If he is making a contribution, why is it necessary to keep up with him and have a dog tag on him?

Dr. WATERMAN. We need to know who the man is, and what his specialty is.

Mr. THOMAS. That is what they called it in the Army when they put that tag on us.

Dr. WATERMAN. We need to know what his specialty is, and what his minor specialties are and where he can be located. It is important to know all scientists in a given region so they can be called upon for special help in case of an emergency.

For general Government planning, this gives a survey of what the distribution of scientists is in the country and those who have specialties. One feature of it which you can hardly get any other way is combined specialties. If you want a man who knows polymer chemistry and who can speak Chinese, or perhaps knows how to teach or something like that, you can find this out through such a register. So, for planning purposes and for mobilization planning and for disaster events, these are some of the chief uses.

Mr. THOMAS. Does anyone do this for physicians?

Dr. WATERMAN. Yes, sir; it is a separate one.

Mr. THOMAS. Do you do it, or someone else?

Dr. WATERMAN. The American Medical Association maintains a directory.

Mr. YATES. What does the register show?

Dr. WATERMAN. It shows the distribution of the people in these qualified fields.

Mr. YATES. Does it show their qualifications and where they are working?

Dr. WATERMAN. Yes.

Mr. YATES. Does it show what his business address is, and where he is working?

Dr. DEES. Yes, sir.

Mr. YATES. Are you sure?

Dr. DEES. Yes, sir.

Dr. WATERMAN. It also shows his affiliation.

PROGRAM DEVELOPMENT, OPERATION AND EVALUATION

Mr. THOMAS. At this point in the record we shall insert pages 291 and 292 of the justifications.

(The pages referred to follow:)

SUPPORT OF SCIENTIFIC MANPOWER

Program development, operation, and evaluation—Obligations by object

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
Average employment	97.0	126.0	132.0	+6.0
Average salary	$7,087	$7,071	$7,030	−$41
01 Personal services:				
Staff	$687,422	$891,000	$928,000	+$37,000
Consultants, panels and division committees	21,891	34,000	48,000	+14,000
Subtotal	709,313	925,000	976,000	+51,000
02 Travel:				
Staff	33,964	53,000	73,000	+20,000
Consultants, panels, and division committees	18,615	28,000	28,000	0
Subtotal	52,579	81,000	101,000	+20,000
03 Transportation of things	980	10,000	11,000	+1,000
06 Printing and reproduction	22,605	27,000	30,000	+3,000
07 Contractual services:				
Administrative	1,361,843	1,138,000	1,186,000	+48,000
Employee life insurance	2,156	3,000	3,000	0
Employee health benefits	0	0	7,000	+7,000
Security investigation	22,094	16,000	10,000	−6,000
Subtotal	1,386,093	1,157,000	1,206,000	+49,000
08 Supplies and materials	270	0	0	0
11 Grants, subsidies, and contributions:				
Contributions to the retirement fund	35,515	47,000	49,000	+2,000
Other	76,081	9,115	0	−9,115
Subtotal	111,596	56,115	49,000	−7,115
15 Taxes and assessments	1,996	2,000	2,000	0
Total	2,285,432	2,258,115	2,375,000	+116,885

The major components of the increased funds for fiscal year 1961 in program development, operation, and evaluation are:

Personal services, +$51,000.—This nominal increase in personal service funds will permit a modest increase in average employment. Each year brings increasing numbers of proposals for Foundation support in the programs of scientific personnel and education. This increasing proposal volume requires a staff to insure prompt handling and efficient review of each proposal. The personal services requested for fiscal year 1961 will permit an average of 132 employees or an increase of 6 in average employment over fiscal year 1960.

Travel, +$20,000.—The increase in scope of the National Science Foundation education in the sciences activities requires that program officials and members of advisory panels travel more frequently so that proper coordination and liaison is maintained with the many professional societies, colleges, universities, and education officials. These contracts and conferences are necessary to insure that the objectives of the Foundation are being met.

Administrative contracts, +$48,000.—Funds requested for administrative contracts in fiscal year 1961 will be used to cover the cost of testing, grading, evaluating, and selecting fellowship applicants for predoctoral, postdoctoral, science faculty, and summer fellowships for high school teachers. In addition, contracts are to be arranged for the purpose of screening proposals under the various programs in the institutes and special projects in science education sections. In previous years, contracts have been negotiated with the Educational Testing Service, the National Academy of Sciences, the Association of American Colleges, and Science Service for these purposes. Contracts of a similar nature will be made in fiscal year 1961 with these and possibly other organizations uniquely qualified to perform these services.

The services rendered by the contracting organizations vary from program to program, but in all these cases, the Foundation seeks contractors who have had long experience in working with the scientists of the United States on problems of a nature similar to those associated with the relevant Foundation program. As an example of the type of service provided, the National Academy of Sciences—in connection with the regular graduate fellowship program—carries out all details of distributing application materials, processing applications and supporting documents as they are returned, selecting and inviting to Washington, D.C., the required number of panelists for the evaluation process, and in other ways rendering services to the Foundation related to the process of evaluating the ability of individual fellowship applicants. In other programs, the National Academy of Sciences, or other contractors, may be asked only to select and bring to Washington, D.C., the screening panelists who are to work on evaluating applications. In most contracts, the Foundation provides for reimbursing the contractor (on a cost-plus percentage overhead basis) for expenses incident to carrying out the work required, including professional and clerical salaries, travel expenses of contractor personnel and panelists, costs of producing and distributing informational materials, and for similar purposes.

Mr. THOMAS. This is program development by the front office; is it not?

How many people do you have? Is that number 132?

Then, we have your "Other objects." This is split up into manpower divisions.

Do you have an overall cover sheet? I think it is in the record.

Where is it? Put your finger on it right quick, and see if we inserted it.

Mr. LUTON. At page 297.

Mr. THOMAS. This is for the entire agency?

Dr. WATERMAN. Yes, sir.

Mr. THOMAS. We shall insert page 297 of the justifications into the record at this point.

(The page referred to follows:)

Executive direction and management—Summary

	Actual, fiscal year 1959	Estimate, fiscal year 1960	Estimate, fiscal year 1961	Increase (+) or decrease (−), fiscal year 1961 over 1960
Average employment	106.0	139.0	156.0	+17.0
Average salary	$7,217	$7,252	$7,282	+$30
01 Personal services:				
National Science Board	11,080	27,000	27,000	0
Office of the Director	155,842	171,000	230,000	+59,000
Consultants and committees	2,190	4,000	5,000	+1,000
Office of General Counsel	50,852	61,000	62,000	+1,000
Administration	558,287	776,000	844,000	+68,000
Subtotal	778,251	1,039,000	1,168,000	+129,000
02 Travel:				
National Science Board	17,482	18,000	18,000	0
Office of the Director	11,864	15,500	16,000	+500
Consultants and committees	2,316	4,000	4,500	+500
Office of General Counsel	230	500	500	0
Administration	7,378	27,000	36,000	+9,000
Subtotal	39,270	65,000	75,000	+10,000
03 Transportation of things	1,310	5,000	5,000	0
04 Communication services	109,070	118,000	135,000	+17,000
05 Rents and utility services	2,718	8,000	7,000	−1,000
06 Printing and reproduction	19,381	23,000	28,000	+5,000
07 Other contractual services:				
Administrative contracts	63,801	45,000	45,000	0
Security investigations	20,912	14,000	5,000	−9,000
Employee life insurance	2,165	2,500	3,000	+500
Employee health benefits	0	0	8,000	+8,000
Subtotal	86,878	61,500	61,000	−500
08 Supplies and materials	51,279	53,000	65,000	+12,000
09 Equipment	143,249	100,000	95,000	−5,000
11 Grants, subsidies, and contributions: Contributions to the retirement fund	43,435	56,000	64,000	+8,000
15 Taxes and assessments	1,008	1,500	2,000	+500
Total	1,275,849	1,530,000	1,705,000	+175,000

Dr. KELLY. That is not for the whole agency.

Mr. THOMAS. No; I want it for the entire agency. Where is it? Under your "other objects", you have your personnel expenditures.

Dr. WATERMAN. The administrative expenses in connection with the science programs are associated with each program.

Mr. LUTON. Page 9.

Mr. THOMAS. It is in the record already; is it not?

Mr. LUTON. Yes, sir:

GRANTS AWARDED IN SUPPORT OF SCIENCE

Mr. THOMAS. Now, you submitted for the record yesterday a breakdown by colleges for support of scientific manpower, but the justifications carry a breakdown of your "Support of science," but it does not for "Manpower." Of course, it is pretty difficult to itemize.

I think it would be well to carry in your justifications next year a complete breakdown of both. You only have a breakdown of your "Science" in your justifications.

In looking over your breakdown for "Science," I find that about four or five States are getting about 40 or 50 percent of your total amount of money, which was $69 million for this year, or was it $86 million?

What is the dollar amount for "Science"?

Dr. WATERMAN. $88 million, I believe it is.

Mr. THOMAS. It is $118 million; is it not?

Mr. LUTON. That is the 1961 estimate.

Dr. WATERMAN. It is $88 million for this year.

Mr. THOMAS. Of course, your tables will show for only 1960. Your basic research is about $79 million for 1961?

Dr. WATERMAN. Yes, sir.

Mr. THOMAS. And there are about five or six States who are receiving 40 to 50 percent of it?

Dr. WATERMAN. We have watched this distribution, Mr. Chairman, and it is interesting that the distribution of research funds from the Foundation goes to States about in proportion to the graduate student population of the States.

Mr. THOMAS. Take, for instance, Alabama, $24,440; Arizona, $635,800, and here is California next on the list with $6,108,449. Then you have Illinois with $4,552,450. Here is Indiana next on the list with $1,389,000.

I am a little bit partial to Iowa, and I see Iowa has $746,950.

My own State of Texas got about $1.5 million, as well as I remember. In numbers it was very small. Texas had $1,182,820.

What does this tabulation show with reference to manpower?

Dr. DEES. Mr. Chairman, the document which was inserted in the record yesterday does show these figures that you have already mentioned, but we did show two totals which you may find of interest. Approximately 450 separate institutions received "Support of scientific manpower" grants either for institutes or in connection with the other types of programs that we support under this heading, and a total of 1,200 grants, in round numbers, were made. The breakdown by States is included in this document.

Mr. THOMAS. Doctor, we just had this 24 hours, or about 12 hours, ago. We C and D students take 4 or 5 days to absorb all this. We cannot absorb it if you have it in your book, and we do not have it in ours.

Dr. DEES. We will see to it that you get it next time.

Mr. THOMAS. It does not take an A-plus student to understand that.

Dr. WATERMAN. These are research grants that you are speaking of rather than manpower?

Mr. THOMAS. Tell us how the money is allocated among the States in "Manpower."

Do four or five States receive 40 percent or 50 percent of it? I cannot believe that A-plus students are all located in four or five States. I imagine some of them are out in the country.

Dr. WATERMAN. In the case of the total money in this program, some of the large grants like these "Course content" things go to where the centers are, and that warps the distribution pattern reflected by the institute and fellowships grants.

Dr. DEES. The distribution of institutes was extremely good last year; we actually carried out an analysis on the basis of total participants by State, and found that this was quite gratifying in the sense that this matched reasonably well on a population basis.

In terms of actual locations, for example, in this document we were talking about, Illinois received $1.3 million, roughly in fiscal year

1959, in the total of approximately $49 million. Indiana received $1.4 million, roughly; Iowa, $1 million; Kansas, $1 million, and, skipping on down, $4.7 million to Massachusetts. This brings out Dr. Waterman's point, because the large course content improvement program at MIT embraces campuses in various parts of the country and people in various parts of the country. Nonetheless, the grant was made to MIT and therefore Massachusetts shows a total of $4.7 million.

GRANTS TO OTHER GOVERNMENT AGENCIES

Mr. THOMAS. I see you are making some grants to France in the amount of $40,250; to Israel in the amount of $4,000; to Puerto Rico in the amount of $18,050; Turkey, $5,200. However, I cannot understand why you are giving these grants to other agencies of the Government.

May I call the committee's attention to pages 040, 041, and 042 of the justifications? Look what we are doing to Government institutions in the District of Columbia.

Dr. WATERMAN. The District of Columbia or educational institutions, Mr. Chairman?

Mr. THOMAS. You have agencies of Government in here; do you not?

Dr. WATERMAN. Yes, sir.

Mr. THOMAS. And, you have the National Academy of Sciences. We understand that. You also have the National Bureau of Standards receiving only $372,000.

Then you have "Antarctic research" and the "International Geophysical Year," where there is $1 or $2 million in here for the International Geophysical Year.

How long does the International Geophysical Year last? It has already gone for 5 years.

Dr. WATERMAN. There is a distinction here. This is what they call International Geophysical Cooperation, which is the aftermath of the IGY, and involves only selective programs.

Mr. THOMAS. How much is in here for it? Is it $2 million or $3 million?

Mr. YATES. In that program?

Dr. WATERMAN. You mean from this list here?

Mr. THOMAS. You have $5.5 million at one spot for it?

Dr. WATERMAN. That is for Antarctic research.

Mr. THOMAS And, then you have four or five agencies here. You must have $6 million or $7 million for it.

Dr. WATERMAN. There is a distinction. The International Geophysical Cooperation does not include the Antarctic research. The Antarctic research is a total of $4 million, divided between certain Federal agencies and also colleges and universities.

Mr. THOMAS. You have the Bureau of Standards listed at $372,000, Antarctic research, $250,000; International Geophysical Year Cooperation, $122,000; the Office of Naval Research, $300,000; atmospheric science, $250,000, and International Geophysical Cooperation again. How much?

Dr. WATERMAN. Well, there is $250,000 to the Office of Naval Research, but the program in International Geophysical Cooperation is broad.

Mr. THOMAS. Then you have the Smithsonian Institution. They get their money in a separate appropriation, and here you subsidize them.

Dr. WATERMAN. I think the Smithsonian, Mr. Chairman, is in a different category. They do not have money for this kind of thing. This is for research done in their museum by people interested in fundamental research.

Mr. THOMAS. What research are they doing?

I notice you have listed biology.

Dr. WILSON. I can speak for biology. Those are studies carried on at places like Barro Colorado Island, where a scientist from a university is attached to the Smithsonian for administrative purposes, but goes to a field laboratory to do the work.

Mr. THOMAS. What about the Coast and Geodetic Survey which also carries Antarctic research in the amount of $122,000?

There is also the Internatioanl Geophysical Cooperation in the amount of $6,000. Then there is the U.S. Geological Survey, Antarctic research, and the U.S. Weather Bureau which carries an amount of $1,447,141.

Dr. WATERMAN. This is the Antarctic program. Those totals on the Antarctic will come under the general heading of Antarctic research which we covered earlier under research, Mr. Chairman, as a separate item, and they fall within that.

Mr. THOMAS. You have at least $4 or $5 million in here for other governmental agencies.

Dr. WATERMAN. We have the responsibility, of course, for the scientific program in the Antarctic, and the money goes to the Federal agencies for that purpose, and also to other agencies like universities and other research institutions to carry out some of the scientific programs in the Antarctic.

Mr. THOMAS. What is the total amount for the Antarctic?

Dr. WATERMAN. We had an item of $4 million for this in 1960, and the current——

Mr. THOMAS. You have $4 million as just a starter. You have another $1.5 million or $2 million back in here with various governmental agencies.

Dr. WATERMAN. I think you will find the totals are all right, except there was an item carried over of about $1.8 million.

Mr. LUTON. We had about $2.2 million carryover from previous years, but this is money that had been made available to other Government agencies which they will expend by fiscal year 1961. Under section 1311 we had to cancel the obligations on June 30 and reobligate on July 1.

Mr. Chairman, part of this money for the Antarctic comes out of the $5.5 million, or the $4 million last year that was appropriated, and all the money for the International Geophysical Cooperation comes out of our basic research grant funds.

Dr. WATERMAN. We have no special fund for that. It is scattered through the research which we support.

A part of it is carried independently with their own money by the Bureau of Standards and other agencies.

Mr. THOMAS. The Navy supports the logistics end of the operation which is another $5 or $6 million.

Dr. WATERMAN. $10 or $12 million.

Mr. YATES. What is the nature of the grant to the Bernice P. Bishop Museum? It says "Research facilities."

Dr. WILSON. That is to build up their systematic biological collections and to purchase new cases for their collection of plants and insects.

RESULTS IN FIELD OF BIOLOGY

Mr. THOMAS. Can you put your finger on anything this year in the way of new information in the field of biology?

You have various fields of biology and have about 40 or 50 contracts and they have been running a long time. What have we come up with in the field of biology in the last 7 or 8 years as a result of these expenditures?

Is there anything this year on which you can put your finger?

Dr. WILSON. I think if one were to put his finger on the most exciting thing in the biological research area, it would be the kind of thing that Dr. Miller of Columbia University and Dr. Fox down at Florida State have been doing on amino acid structure. These are the basic building blocks of living tissue. Dr. Fox, in the last year or two has gone ahead to a point where he is now convinced that "primary" amino acids function as a sort of "transfer agent" for nitrogen. This does not mean much to you perhaps, but what I am saying is that he believes he has shown in such work that the basic structural aspect of living tissue, through an evolutionary stage, takes on a fundamental functional role.

If you ask a biologist, this is pretty exciting, because he starts thinking, for example, of what life on Mars might be like, if there is life there at all. The speculation is that it may be something that a biologist would refer to as "amino acid soup." These are not living tissues in the sense of a human being, but in the sense of a replicative material, which may be the core of the life process.

With respect to other parts of biology, this sort of development is exciting in the sense that when you start thinking about the basic building blocks of living tissue, you start thinking about its genetic aspects. The matter of the biochemical nature of the gene for example, is directly related. The kind of outside evidence that would support my contention that the area is exciting and important is the fact that in the last 2 years Nobel prizes have been awarded to American scientists working in this area of biology.

Now, if you think of the life science spectrum, the next step that one might think of from this basic building block concept, is the basic substructure of enzymes. This is becoming more familiar territory to you since you have read about enzymes. Enzymes do certain kinds of things in cellular and physiological activities.

In this area we have recently made a grant to Dr. Chance of the University of Pennsylvania. Dr. Chance has adapted physical science techniques to a point where they are yielding information as to the way energy changes take place; for example, how light energy is changed to chemical energy in living tissue. Here is where photosynthesis comes in. In a different sense, the matter of what is the basic structure of living material is exciting when you start talking about viruses. The fundamental nature of viruses appears to be that they are some form of relatively simple biochemical structure.

Mr. EVINS. There are other exciting things in the field, I am sure. I have not heard all the testimony, but what are your big problems that you would like to attack principally, Dr. Waterman?

Dr. WATERMAN. In research or the whole program?

Mr. EVINS. The whole program.

Dr. WATERMAN. We want to be sure competent research scientists in the country have what they need to work with. This is important so they can get on with the progress in science.

Second, they need to have research facilities where these are really required. Some of these are extremely costly, but if the scientists say they cannot learn further in a particular aspect of science without these facilities, then we have to take it seriously.

Then, one immediate problem I spoke about is some way in which we can help the strength and flexibility of the institutions themselves. This is quite a problem. If they cannot do this locally, the thing we are sure of is it must be done. Where the Federal Government does this, and how, is always a question. One would like to see private universities subsist on their own endowments, but that day seems to have passed. So if they are to do the kind of work which we think science should do, and which the country expects of them, then we have to find ways to help them do it. Therefore we have ways of training the teachers, we have fellowships, research grants and grants which involve a certain degree of training, and certain facilities if we find they have to have them. Aside from that there is the whole problem of strengthening education in science, the training of teachers, the identification of people with aptitudes, and provision of opportunities for those who have the aptitudes to carry through and go as far with their professional training as can be done.

Finally, we feel it is most important in these days when scientific and technical questions are becoming national issues that the people as a whole should have some appreciation of what it is that science does, what basic research means, and how this gets translated into things that matter.

Mr. EVINS. Does the Bureau of the Budget have an absence of appreciation of your overall request? How much did they deny you, or did they give you the full limit of your request?

Dr. WATERMAN. Each year in the President's budget we have been allowed an increase. In direct answer to your question, we asked for $214,835,000 and we were allowed $190 million.

Mr. BOLAND. I hope in the record with regard to the challenge to education you document that in detail so that we can stir the feelings of the American people. I think that the greatest challenge that faces America is with reference to education. We do not seem to be able to stir the imagination of the American people as it ought to be stirred.

Dr. WATERMAN. We will be very happy to cooperate in that. I feel sure the important thing is to bring an understanding of these problems home to the citizens of the country. That is really the way to get things done.

Mr. BOLAND. I think a better record is being made here with reference to this problem than in any committee I have sat on. The full Appropriations Committee heard Admiral Rickover. I read what might be called the rebuttal by Dr. Derthick, the Commissioner of

Education. I think that a better record has been written here. I think that it will be a useful record.

Mr. JONAS. I think that we ought to take notice of the fact that our old friend Dr. Klopsteg is here. I see that you are carried on the list as a special consultant. We are glad to have you.

SCIENTISTS OF TOMORROW

Now, I want to ask Dr. Kelly what developments have occurred in the past year with our friend out in Oregon that runs Scientists of Tomorrow. Are they still operating?

Dr. KELLY. We have not heard from them this year. Have you heard from him?

Mr. JONAS. I have a letter but I do not think he would want me to read it. He said that you sent an evaluator to call on Dean Gilfillan of the School of Science at Oregon State College, and he started off by criticizing the program as if it had been prejudged before he asked any questions. I wonder who your evaluator was?

Dr. KELLY. I would be much surprised if our staff acted that way. We are all very careful to behave like good civil servants.

Mr. JONAS. Do you know who was sent out there?

Dr. DEES. We had an evaluation contract this past year, Mr. Jonas, with Science Research Associates in Chicago, and they undertook—under this contract—to get some consultants that visited a number of projects of this nature. Certainly no one we sent from our organization would have dared do a thing of that kind. I would have to check with the contractor to find out who the person was and what the basis of his comments may have been.

Mr. JONAS. We did not invite the report; it just came in. I thought it was worthwhile calling to your attention for any comment you might want to make. They run an institute down in my part of the country at Clemson College, and that institution continues to renew with them, so I take it from that they find it a very satisfactory arrangement.

Dr. KELLY. Our position is that we want to encourage non-Federal agencies, industry, and the like, and not discourage them. The Scientists of Tomorrow group wanted us to support them financially, and we would rather make grants for such projects directly to the colleges and universities rather than through a middleman.

Mr. JONAS. Did they not ask you to support the institutions, the host college?

Dr. KELLY. Oh, yes, but we did not have enough money to support all of the proposals. I think we were able to support only about a fourth.

Dr. DEES. I think that is correct.

Mr. JONAS. You could not get around to theirs?

Dr. KELLY. That is right.

Mr. THOMAS. Thank you gentlemen. It is always nice to do business with you. I hope that you gentlemen, Dr. Waterman and your staff, will work these programs over carefully. You go up $30 or $35 million every year. The committee likes to go along with you, but let us not break our necks now by our own speed and get tripped up going around the corner. Let us take it a little easy. We have had an educational system in this country for 150 years or more, and we have not done too badly. Let us not try to overhaul it com-

pletely in 2 or 3 years and bring about revolutionary changes that the public is not going to accept.

Mr. YATES. And that leads me to my question, how much money did you ask the Bureau of the Budget for?

Dr. WATERMAN. $214,835,000.

Now, I would like to say this, scientists are picking it up and others too—the analogy in the development of nuclear energy. You will recall one could not make a nuclear atomic bomb until he got what the scientists called a critical mass, and then everything clicked. Well, we feel about this educational program, the kind of things we are doing, the summer institutes, will develop an interest in getting these things done and when it reaches a critical mass these things everybody will do. We are hoping this will happen.

Mr. THOMAS. You are touching the teachers and the teachers are very close to the students and the students are very close to mama and papa, so you really have something there in your institutes. I expect when it is all said and done that is by far the best part of your program. Maybe your fellowships are equally as important. If you pursue those two programs carefully it looks to me you might be able to cut out some of your other programs. If these two do not produce results your others will not. You ought not start running the 100-yard dash in 9.2. You better take it easy for the first 100 yards.

Mr. JONAS. Can you cite any case where any beneficiary of this program has received a prize such as the Nobel Prize for work he has done, or any other significant breakthrough in any field?

Dr. WATERMAN. We supported many of the scientists that Dr. Wilson mentioned here.

Dr. WILSON. I think that it should be pointed out the Nobel Prize usually follows about 8 or 10 years of work.

(Discussion off the record.)

Mr. JONAS. Do you have any case that you can cite us for the record of beneficiaries of the program who have made significant contributions, who have received honors for their work?

Dr. WATERMAN. We can furnish that information for the record.

(The requested information follows:)

National Science Foundation Honors and Awards Received by Recipients of Basic Research Grants

Mathematical, physical, and engineering sciences

ASTRONOMY

Name	Institution	Honor or award
Burbidge, E. Margaret; Burbidge, Geoffrey.	Yerkes Observatory, University of Chicago.	Helen B. Warner Prize of the American Astronomical Society.
Goldberg, Leo	University of Michigan	Election to National Academy of Sciences.
Greenstein, Jesse L	Mount Wilson and Palomar Observatories, California Institute of Technology.	Do.
McMath, Robert R	University of Michigan and AURA.	(1) Election to National Academy of Sciences. (2) Wetherill Medal of Franklin Institute. (3) President's Medal for Merit.
Meinel, Aden	Kitt Peak National Observatory.	(1) Helen B. Warner Prize of the American Astronomical Society. (2) Lomb Prize of the Optical Society of America.
Morgan, W. W	Yerkes Observatory, University of Chicago.	(1) Election to National Academy. (2) Catherine Wolfe Bruce Gold Medal of the Astronomical Society of the Pacific.
Nassau, J. J	Case Institute of Technology	Case Achievement Award.
Schwarzschild, Martin	Princeton University	(1) Election to National Acaddemy. (2) Newcomb Cleveland Prize of the American Association for the Advancement of Science.
Strömgren, Bengt	Institute for Advanced Study.	Catherine Wolfe Bruce Gold Medal of the Astronomical Society of the Pacific.
Struve, Otto	National Radio Astronomy Observatory.	(1) Gold Medal, Royal Astronomical Society. (2) Bruce Gold Medal. (3) Draper Gold Medal (National Academy). (4) Rittenhouse Medal. (5) Russell Lecture of American Astronomical Society. (6) Elected a corresponding member of the French Academy of Sciences.
Van Biesbroeck, George	Yerkes Observatory, University of Chicago.	(1) Gold Medal, Academy Copenhagen. (2) Donahoe Comet Medal. (3) Burr Prize, National Geographic Society. (4) James Craig Watson Medal of the National Academy of Sciences.
Walker, Merle F	Lick Observatory, University of California.	Helen B. Warner Prize. American Astronomical Society.
Whipple, Fred L	Smithsonian Astrophysical Observatory.	(1) Election to National Academy of Sciences. (2) Donohue Medals. (3) Presidential Certificate of Merit. (4) Smith Medal (National Academy).

ATMOSPHERIC SCIENCES

Bjerknes, Jacob (jointly with Erik Palmen).	University of California	Carl-Gustaf Rossby Award.
Byers, Horace R	University of Chicago	The Charles Franklin Brooks Award.
Fleagle, Robert G	University of Washington	The Clarence LeRoy Meisinger Award.
Moore, Charles B. (jointly with Comdr. Malcolm D. Ross).	Arthur D. Little, Inc	Special award.
Petterssen, Sverre	University of Chicago	Gold Medal Award.

CHEMISTRY

Name	Institution	Honor or award
Corey, E. J	Harvard University	American Chemical Society Award in Pure Chemistry.
Djerassi, Carl	Stanford University	Do.
Grunwald, Ernest M	Florida State University	Do.
Stork, Gilbert J	Columbia University	Do.
Brown, H. C	Purdue University	American Chemical Society Award for Creative Work in Synthetic Organic Chemistry.
Johnson, W. S	University of Wisconsin	Do.
Woodward, R. B	Harvard University	Do.
Debye, Peter J	Cornell University	Nobel Laureate; Kendall Award.
Emmett, Paul H	Johns Hopkins University	Kendall Award.
Ferry, John D	University of Wisconsin	Do.
Pickett, Lucy W	Mount Holyoke College	Garvin Medal.
Buchi, George H	Massachusetts Institute of Technology.	Fritsche Award.
Djerassi, Carl	Stanford University	Do.
Swain, C. Gardner	Massachusetts Institute of Technology.	American Chemical Society Award.
Kistiakowsky, G. B	Harvard University	Gibbs Medal.
Libby, Willard	University of California, Los Angeles.	Do.
Noyes, W. A	University of Rochester	Do.
Brown, H. C	Purdue University	Nichols Medal (New York section of American Chemical Society).
Culbertson, James B	Cornell College	Manufacturing Chemists Association Award.
Dyer, Elizabeth	University of Delaware	Do.
Fieser, Louis F	Harvard University	Do.
Jonassen, Hans B	Tulane University	Do.
Powell, R. E	University of California, Berkeley.	Do.
Scott, A. F	Reed College	Do.
Thiessen, G. W	Monmouth College	Do.

EARTH SCIENCES

Ewing, W. Maurice	Lamont Geological Observatory.	Agassiz Medal; William Bowie Medal; Vetlesen Award.
Nier, Alfred O	University of Minnesota	Day Medal.
Verhoogen, John	University of California, Berkeley.	Do.

ENGINEERING SCIENCES

Eliassen, Rolf	Massachusetts Institute of Technology.	George Westinghouse Award.
Gerand, George	New York University	Curtis W. McGraw Research Award of Engineering College Research Council.
Kline, Stephen J	Stanford University	Melville Medal, ASME.
Marin, Joseph	Penn State	George Westinghouse Award.
Marshall, W. R., Jr	University of Wisconsin	Professional Progress Award of AICHE.
Mehl, Robert F	Carnegie Institute of Technology.	Vincent Bendix Gold Medal, ASEE.
Oldenburger, Rufus	Purdue University	International Federal of Automatic Control Award.
Peters, Max S	University of Illinois	George Westinghouse Award.
Rinehart, John S	Colorado School	Presidential Certificate of Merit.
Rouse, Hunter	State University of Iowa	George Westinghouse Award.
Shaw, Milton C	Massachusetts Institute of Technology.	Do.
Sliepcevich, C. M	University of Oklahoma	Curtis W. McGraw Research Award of Engineering College Research Council.
Treybal, Robert E	New York University	George Westinghouse Award.

MATHEMATICAL SCIENCES

Name	Institution	Honor or award
Bruck, R. H	University of Wisconsin	Chauvenet Prize.[1]
Courant, Richard	New York University	Navy Distinguished Service Award.
Harish-Chandra	Columbia University	Frank Nelson Cole Prize.[2]
Kodaira, Kemihiko	Princeton University	Fields Medal.
McShane, E. J	University of Virginia	Chauvenet Prize.[1]
Rosenlicht, Maxwell A	University of California, Berkeley.	Frank Nelson Cole Prize.[2]
Selberg, Atle	Institute for Advanced Study	Fields Medal.
Stoker, James J	New York University	Dannie Heineman Prize.[3]
Tate, John	Harvard University	Frank Nelson Cole Prize.[2]

[1] Chauvenet Prize: Awarded every 3 years for a noteworthy expository paper in mathematics.
[2] Frank Nelson Cole Prize: Awarded twice every 5 years for notable research, once in algebra, once in the theory of numbers.
[3] Dannie Heineman Prize: Awarded every 3 years for an outstanding expository book in mathematics.

PHYSICS

Beams, Jesse W	University of Virginia	John Scott Medal.
Daunt, John G	Ohio State University	33d Dudell Medal.
Glaser, Don A	University of Michigan	Charles Boys Prize of British Physical Society.
Ingram, Mark G	University of Chicago	J. Lawrence Smith Medal.
Kittel, Charles	University of California, Berkeley	Oliver E. Buckley Solid-State Physics Prize.
Kusch, Polycarp	Columbia University	Nobel Prize in Physics.
Weber, Joseph	University of Maryland	Gravity Research Foundation Award.

SOCIAL SCIENCES

Siegal, Sidney	Penn State	Monograph Prize of the American Academy of Arts and Sciences.
Festinger, Leon	Stanford University	Distinguished Contributor Award, American Psychological Association.
Coon, Carleton S	Penn State	Election to National Academy of Sciences.
Haury, Emil W	University of Arizona	Do.
Herskovits: Melville J	Northwestern University	Do.
Movius, Hallam O., Jr	Harvard University	Do.
Smith, Cyril Stanley	University of Chicago	Do.
DeSantillana, Giorgio	Massachusetts Institute of Technology.	Guggenheim Foundation fellow.
Beardsley, Richard K	University of Michigan	Do.
Sebeok, Thomas A	Indiana University	Do.

Biological and medical sciences

DEVELOPMENTAL

Bang, F. B	Johns Hopkins University	NRC fellow; Fulbright scholar.
Boell, E. J	Yale University	Fulbright fellow; Rockefeller fellow.
Bonner, J. T	Princeton University	Rockefeller fellowship (traveling); Guggenheim fellow, Waksman Award; Member, NAS.
Clement, A. C	Emory University	Guggenheim fellow.
Cleveland, L. R	Harvard University	NRC fellow; member, NAS.
Costello, D. P	University of North Carolina	NRC fellow.
Erickson, R. E	University of Pennsylvania	Guggenheim fellow.
Goodrich, H. B	Wesleyan University	Honorary Science Degree, Hamline, 1952; Amherst, 1954.
Lash, J	University of Pennsylvania	Whitney Foundation fellow.
Mazia, D	University of California	NRC fellow.
Metz, C. B	Florida State University	Do.
Raper, K. B	University of Wisconsin	Member, NAS.
Rudnick, D	Albertus Magnus College	NRC fellow; Guggenheim fellow.
Selye, H	University of Montreal	Honorary Dr. Nat. Univs., Argentina; Rockefeller fellow; Casgrain and Charbonneau Prize; Medal, Accad. Med. Fisica, Italy, 1950; fellow Royal Society, Canada.
Schmidt, G	Boston Dispensary	Rockefeller fellow.
Thornton, C. S	University of Wyoming	Fulbright fellow.
Villee, C. A	Massachusetts General Hospital.	Guggenheim fellow.
Wetmore, R. H	Harvard University	Honorary Sc. Dl, Acadia, 1948; NRC fellow; member, NAS.
Williams, R. G	University of Pennsylvania	NRC fellow.

ENVIRONMENTAL

Name	Institution	Honor or award
Bormann, F. H	Dartmouth College	George Mercer Award.
Burholder, Paul	Brooklyn Botanic Garden	Member, NAS.
Cain, Stanley	University of Michigan	Honorary degree, University of Montreal; distinguished professorship, University of Michigan.
Carr, Archie	University of Florida	Daniel Geraud Elliott Medal.
Chaney, Ralph	University of California	Member, NAS.
Gerking, Shelby	University of Indiana	George Mercer Award.
Hasler, Arthur	University of Wisconsin	President elect, Ecological Society.
Humm, Harold	Duke University	Jacques Loeb associate in marine biology, a Rockefeller Institute fellowship, to work at Marine Biological Laboratory.
Hubbs, Carl	University of California	Member, NAS.
Ketchum, Bostwick	Woods Hole Oceanographic Institute.	President, ASLO.
MacArthur, Robert	University of Pennsylvania	George Mercer Award.
Odum, Eugene	University of Georgia	Do.
Odum, Howard T	University of Texas	Do.
Painter, R. H	Kansas State College	Gamma Sigma Delta national award for distinguished service to agriculture.
Park, Thomas	University of Chicago	President elect, AAAS.
Sargent, Frederick II	University of Illinois	Award from International Society for Bioclimatology and Biometeorology, for achievement in bioclimatology.
Went, Frits W	California Institute of Technology.	President, Botanical Society Distinguished Botanist; member, NAS.

FACILITIES

Hendricks, Sterling B	U.S. Department of Agriculture.	Presidential citation; member, NAS.
Long, C. N. H	Yale University	Pharmaceutical Manufacturing Award; member, NAS.
Thimann, Kenneth V	Harvard University	Member, NAS.

GENETIC

Anderson, Edgar	Missouri Botanical Garden	Member, NAS; Guggenheim fellow; Order of Yugoslavian Crown.
Bonner, David	Yale University	Member, NAS.
Brink, R. A	University of Wisconsin	Do.
Cooper, K. W	University of Rochester	Guggenheim fellow.
Delbruck, M	California Institute of Technology.	Member, NAS; Rockefeller Foundation fellow.
Dobzhansky, Th	Columbia University	Member, NAS.
Delisle, A. L	University of Notre Dame	Cabot research fellow.
Demerec, M	Long Island Biological Association.	Member, NAS; Order of St. Sava, Yugoslavian Government.
Eisenstark, A	Kansas State University	Guggenheim fellow.
Fox, A. S	Michigan State College	Fulbright fellow.
Ginsburg, B. E	University of Chicago	Sheldon fellow.
Grant, V	Rancho Santa Ana Bontanic Garden.	NRC fellow.
Green, M. M	University of California	Guggenheim fellow.
Heiser, C. B	Indiana University	Do.
Horowitz, Norman	California Institute of Technology.	NRC fellow; Guggenheim fellow; Fulbright fellow.
Kalckar, Herman	Johns Hopkins University	Member, NAS.
Lederberg, J	Stanford University	Nobel Prize; Pasteur Award; member, NAS.
Lerner, M	University of California	Guggenheim fellow; Borden Award; Research Prize, Poultry Science Association; member, NAS.
Lewis, H	do	Guggenheim fellow; NRC fellow.
Mangisdorf, F. C	Harvard University	Member, NAS.
Novitski, E	University of Missouri	Guggenheim fellow.
Owen, R	California Institute of Technology.	Gosney fellow.
Plaine, H. L	Ohio State University	NRC fellow.
Raper, J. R	Harvard University	Do.
Rhoades, Marcus	Indiana University	Member, NAS.
Rick, C. M	University of California	Guggenheim fellow; Campbell Award.
Roman, H	University of Washington	Guggenheim fellow.
Ross, James G	South Dakota State College	Do.
Stalker, H. D	Washington University	NSF senior postdoctoral.
Sears, E. R	University of Missouri	Stevenson Award.
Sonneborn, T	Indiana University	Member, NAS; NRC fellow; Prize AAAS.
Stern, Curt	University of California	Member, NAS; Sigma Xi lecturer.
Starr, R. C	Indiana University	Fulbright fellow.

GENETIC—Continued

Name	Institution	Honor or award
Taylor, Herbert	Columbia University	Sigma Xi national lecturer.
Thomas, C. A., Jr	Johns Hopkins University	NRC fellow.
Treffers, H. P	Yale University	Fulbright fellow.
Walters, M. S	Santa Barbara Botanic Garden.	Guggenheim fellow.
Warren, D. C	Purdue University	Borden Award; Research Prize, Poultry Science Association.
Witschi, E	State University of Iowa	Rockefeller Foundation fellow; Sigma Xi national lecturer; president, American Society of Zoology.
Wright, Sewall	University of Wisconsin	Member, NAS.

METABOLIC

Chaikoff, I. L	University of California	Endocrine Award.
Friedmann, Herbert	Smithsonian Institute	Daniel Giraud Elliott Medal for his book, "The Honey Guides."
Knight, Stanley G	University of Wisconsin	3d award of the University of Wisconsin for his research establishing a glycerine derivative, triacetin, as a new fungicide.
Lipmann, Fritz	Rockefeller Institute	Nobel Laureate; member, NAS.
Mirov, Nicholas T	University of California	Distinguished Service Award of U.S. Department of Agriculture.
Nash, Jr., Thomas P	University of Tennessee	ACS, Memphis Section, for "distinguished service to professional chemistry in Southern States."
Wright, Lemuel D	Cornell University	Borden Award in Nutrition; American Institute of Nutrition Award for new microbiological assay procedures for vitamins and discovery of biocytin.
Barker, Horace A	University of California	Member, NAS.
Van Niel, C. B	Stanford University	Do.
Vickery, H. B	Connecticut Agricultural Experiment Station.	Do.
Wilson, Perry	University of Wisconsin	Do.

MOLECULAR

Alberty, R	University of Wisconsin	Eli Lilly Award.
Anderson, Thomas F	Institute for Cancer Research	Silver Medal of Institute Pasteur, Guggenheim fellow.
Baldwin, R. L	Stanford University	Guggenheim fellow.
Blinks, Lawrence	Hopkin's Marine Station	Member, NAS; Stephen Hales Prize.
Bloch, Konrad	University of Chicago	Member, NAS.
Boyer, P. D	University of Minnesota	Paul-Lewis Laboratories Award.
Chance, Britton	University of Pennsylvania	Member, NAS; President's Science Advisory Committee; Presidential Certificate of Merit.
Cohn, Mildred	Washington University	Established investigator of the American Heart Association.
Colowick, Sidney V	Vanderbilt University	Eli Lilly Award.
Coon, M. J	University of Michigan	Paul-Lewis Laboratories Award.
Doty, Paul	Harvard University	American Chemical Society Award.
Edsall, John T	do	Member, NAS.
Fruton, J. M	Yale University	Member, NAS; Eli Lilly Award.
Gross, J	Massachusetts General Hospital.	Established investigator of the American Heart Association.
Heidelberger, Michael	Rutgers University	Member, NAS; Ehrlich Silver Medal; Chevalier, Legion d'Honneur; Lasker Award.
Kabat, Elvin A	Columbia University	Eli Lilly Award.
Kaplan, Nathan	Brandeis University	Eli Lilly Award in Biochemistry.
Koffler, H	Purdue University	Eli Lilly Award in Bacteriology.
Kornberg, Arthur	Stanford University	Nobel Prize.
Lardy, H. A	University of Wisconsin	Paul-Lewis Laboratories Award; Carl Neuberg Medal.
Lehninger, Albert	Johns Hopkins University	Member, NAS; Paul-Lewis Laboratories Award.
Luria, S. E	Massachusetts Institute of Technology.	Nieuwland lecturer, Notre Dame.
Pauling, Linus	California Institute of Technology.	Nobel Prize.
Solomon, A. K	Harvard University	Board of editors, Journal of General Physiology.
Szent-Gyorgyi, Albert	Woods Hole Marine Biological Laboratory.	Member, NAS; Cameron Prize; Lasker Award.
Vennesland, Birgit	University of Chicago	Stephen Hales Prize.
Wald, George	Harvard University	Member, NAS; Eli Lilly Award; Lasker Award.
Warner, R. C	New York University	Representative of American Society of Biological Chemists to Division of Medical Sciences, NAS.

MOLECULAR—Continued

Name	Institution	Honor or award
Watson, James D	Harvard University	Eli Lilly Award in Biological Chemistry.
Westheimer, G. H	do	Member, NAS.
Wood, Willis A	Michigan State University	Eli Lilly Award.
Wyckoff, Ralph W. G	University of Arizona	Member, NAS.

PSYCHOBIOLOGY

Asch, Solomon	Swarthmore College	Invited scholar, IAS.
Beach, Frank A	University of California	Invited scholar, Center for Advanced Study in the Behavioral Sciences; APA distinguished scientific contribution award, 1958, member, NAS.
Emlen, John T	University of Wisconsin	Guggenheim fellow.
Estes, William K	Indiana University	Invited scholar, Center for Advanced study in the Behavioral Sciences.
Gibson, Eleanor	Cornell University	Invited scholar, IAS.
Held, Richard	Brandeis University	Do.
Hovland, Carl I	333 Cedar St., New Haven, Conn.	APA distinguished scientific contribution award, 1957.
Kohler, Wolfgang	Dartmouth College	Invited scholar, IAS; member, NAS; APA distinguished scientific contribution award, 1956.
Lindsley, D. B	University of California	Member, NAS; APA distinguished scientific contribution award, 1959.
Meehl, P. E	University of Minnesota	APA distinguished scientific contribution award, 1958.
Michener, Charles D	University of Kansas	Guggenheim fellow.
Miller, Neal	Yale University	APA distinguished scientific contribution award, 1959; member, NAS.
Pfaffmann, Carl	Brown University	Member, NAS.
Richter, Curt P	Johns Hopkins University	APA distinguished scientific contribution award, 1957.
Skinner, B. F	Harvard University	Member, NAS; APA distinguished scientific contribution award, 1958; Guggenheim fellow.
Stevens, S. Smith	do	Member, NAS.
Von Bekesy, Georg	do	Do.

REGULATORY

Code, Charles F	Mayo Associates	Theobald Smith Medal and Award, AAAS.
Dixon, Frank J., Jr	University of Pittsburgh	Theobald Smith Award; Parke-Davis Award in Experimental Pathology.
Forster, R. P	Dartmouth College	Guggenheim fellow.
Gilbert, Perry	Cornell University	Do.
Gorbman, Aubrey	Oregon State College	Do.
Hisaw, F. L	Harvard University	Member, NAS.
Hungate, R. E	State College of Washington	Guggenheim fellow.
Robertson, O. H	Stanford University	Member, NAS.
Stebbins, R. C	University of California	Guggenheim fellow.
Skoog, F. K	University of Wisconsin	Stephen Hales Prize.
Adolph, B. F	University of Rochester	Presidential Certificate of Merit.

SYSTEMATIC BIOLOGY

Steere, William C	New York Botanical Garden	Honary degree, docteur-es-sciences, University of Montreal.
Wood, Richard	University of Rhode Island	Fulbright Award.
Coolidge, Harold	National Academy of Sciences, National Research Council.	King of Cambodia made him an Officer of Monisaraphon, an order of merit for literary and scientific service.
Cuatrecasas, Jose	Smithsonian Institution	Cruz de Boyaca, decoration by Government of Colombia.
Banner, Albert H	University of Hawaii	Fulbright Award.
Bigelow, H. B	Yale University	Member, NAS.
Barksdale, Alma	New York Botanical Garden	Carnegie fellow; NRC fellow; Guggenheim fellow.
Anderson, Sidney	University of Kansas	Honorarium, American Society of Mammalogists.
Townes, Henry K., Jr	University of Michigan	NRC fellow.
Couch, John	University of North Carolina	Member, NAS; Walker Grand Prize; Elliot Gold Medal.
Keck, David D	New York Botanical Garden	Mary Soper Pope Medal.
Romer, Alfred	Harvard University	Member, NAS; AAAS Council.
Bailey, Irving W	do	Member, NAS.
Mayr, Ernst	do	Member NAS; Joseph Leidy Medal.
Weber, Neal	Swarthmore College	New State Department science officer for Buenos Aires; honorary degree from University of North Dakota.

SYSTEMATIC BIOLOGY—Continued

Name	Institution	Honor or award
Silva, Paul	University of Illinois	Guggenheim fellow; Darbaker Award.
Howard, Richard	Harvard University	Cooley Award.
Munz, Philip	Rancho Santa Ana Botanic Garden.	Certificate of merit from the Botanical Society of America.
St. John, Harold	University of Hawaii	Honorary member, Botanical Society of America.
Taylor, William R	University of Michigan	Foreign corresponding member of the Institut de France, Academie des Sciences.
Hungerford, Herbert	University of Kansas	Joseph Leidy Medal.
Tukey, H. B	Michigan State College	Honorary degree of doctor of horticultural science at Hannover Institute, Hannover, Germany.
Schmidt, Karl P. (deceased)	Chicago Natural History Museum.	Member, NAS; Eminent Ecologist Award of Ecological Society of America; Guggenheim Award.
Alexander, Charles P	University of Massachusetts	Honorary doctor of science degree, University of Massachusetts.
Archer, Allan	Union University	H. B. Rackham postdoctoral fellow.
Abbe, Ernst C	University of Minnesota	Guggenheim Award.
Axelrod, Daniel	University of California	Do.
Boke, Norman	University of Oklahoma	Do.
Bolin, Rolf	Stanford University	Do.
Braun, Emma Lucy	Ohio Academy of Science	Do.
Cable, Raymond M	Purdue University	Do.
Correll, Donovan S	Texas Research Foundation	Do.
Thorne, Robert	State University of Iowa	Do.
Cutler, Hugh	Missouri Botanical Garden	Do.
Dodge, Carroll W	Washington University	Do.
Dawson, E. Yale	Beaudette Foundation	Do.
Durham, John W	University of California	Do.
Emerson, Alfred E	University of Chicago	Do.
Foster, Adriance S	University of California	Do.
Fulford, Margaret	University of Cincinnati	Do.
Garay, Leslie A	Harvard University	Do.
Gates, Gordon E	University of Maine	Do.
Gordon, Myron	New York Zoological Society	Do.
Gressitt, J. Linsley	Bernice P. Bishop Museum	Do.
Hall, E. Raymond	University of Kansas	Do.
Harper, Francis	Arctic Institute of North America.	Do.
Illg, Paul	University of Washington	Do.
Jones, George N	University of Illinois	Do.
Lane, Frederico	American Museum of Natural History.	Do.
Lewis, Harlan	University of California	Do.
Linsley, Earle S	do	Do.
McClung, Leland S	Indiana University	Do.
McClure, F. A	Smithsonian Institution	Do.
Mohr, John L	University of Southern California.	Do.
Morton, Conrad	Smithsonian Institution	Do.
Ownbey, Gerald B	University of Minnesota	Do.
Ownbey, Marion	State College of Washington	Do.
Papenfuss, George F	University of California	Do.
Polounin, Nicholas	College of Arts and Sciences, Iraq.	Do.
Proskauer, J. M	University of California	Do.
Remington, Charles L	Yale University	Do.
Ripley, S. Dillon	do	Do.
Ross, Edward S	California Academy of Science	Do.
Ross, H. H	Illinois State Natural History Survey.	Do.
Schneirla, T. C	American Museum of Natural History.	Do.
Schultes, Richard E	Harvard University	Do.
Schuster, Rudolph	University of Massachusetts	Do.
Sharp, Aaron J	University of Tennessee	Do.
Singer, Rolf	Bertram and Roberta Stein Neuropsychiatric Research Program, Inc.	Do.
Smith, Albert C	Smithsonian Institution	Do.
Stannard, L. J	University of Illinois	Do.
Stebbins, G. L	University of California	Guggenheim Award and member, NAS.
Steward, Albert N. (deceased).	State College of Oregon	Guggenheim Award.
Stirton, R. A	University of California	Do.
Stunkard, Horace	New York University	Do.
Thompson, Rufus H	University of Kansas	Do.
Tinkham, Ernest R	Box, 306 Indio, Calif	Do.
Twitty, Victor C	Stanford University	Guggenheim Award and member, NAS.
Wilson, Mildred S	Smithsonian Institution	Guggenheim Award.
Wilson, Robert W	University of Kansas	Do.
Yuncker, Truman G	DePauw University	Do.

Mr. THOMAS. We thank you gentlemen very much.

MONDAY, MARCH 14, 1960.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WITNESSES

DR. T. KEITH GLENNAN, ADMINISTRATOR
DR. HUGH L. DRYDEN, DEPUTY ADMINISTRATOR
RICHARD E. HORNER, ASSOCIATE ADMINISTRATOR
MAJ. GEN. DON R. OSTRANDER, DIRECTOR, OFFICE OF LAUNCH VEHICLE PROGRAMS
DR. ABE SILVERSTEIN, DIRECTOR, OFFICE OF SPACE FLIGHT PROGRAMS
IRA H. ABBOTT, DIRECTOR, OFFICE OF ADVANCED RESEARCH PROGRAMS
ALBERT F. SIEPERT, DIRECTOR, OFFICE OF BUSINESS ADMINISTRATION
RALPH E. ULMER, BUDGET OFFICER
JAMES P. GLEASON, ASSISTANT ADMINISTRATOR FOR CONGRESSIONAL RELATIONS
DR. WILLIAM H. PICKERING, DIRECTOR, JET PROPULSION LABORATORY
HARRY J. GOETT, DIRECTOR, NASA GODDARD SPACE FLIGHT CENTER
DR. WERNHER VON BRAUN, DIRECTOR, DEVELOPMENT OPERATIONS DIVISION, ARMY BALLISTIC MISSILE AGENCY, ARMY ORDNANCE MISSILE COMMAND

Mr. THOMAS. The committee will please come to order.

We have with us this morning the National Aeronautics and Space Administration. We certainly have a crowd of distinguished gentlemen with us. We are delighted and honored to have all of you.

Do you have a statement for us, Dr. Glennan?

GENERAL STATEMENT

Dr. GLENNAN. I have a brief one that I would like to read, if I may.

It is my privilege to present the National Aeronautics and Space Administration's $915 million budget appropriations request for fiscal year 1961. This sum will support an aggressive, broadly based space exploration program essential to our national security.

NASA takes seriously its responsibility for a program of this magnitude in the complex and costly business of space research and development. If the Congress approves the funds requested, the United States will be able to move solidly toward its long-range goal of manned flight to the moon and planets. In the shorter range, we confidently expect to reassert the leadership of this Nation in the many branches of technology involved in making possible the prose-

cution of a program of scientific research that must certainly lead to applications that will benefit mankind the world over.

The $915 million request is broken down as follows: $621,453,000 for "Research and development"; $122,787,000 for "Construction and equipment"; $170,760,000 for "Salaries and expenses."

I think it would also be useful to break the request down by program as follows: $129,379,000 for the Office of Advanced Research Programs, which is charged with advanced research in aeronautics and astronautics; $370,132,000 for the Office of Space Flight Programs, which directs mission planning, payload design, and in-flight research and operation; $403,023,500 for the Office of Launch Vehicle Programs, which will develop and launch rocket vehicles; $12,465,500 for program direction, which includes headquarters operation.

Before we get into a detailed explanation of our programs and funding requests, I would like to set forth my evaluation of the position and responsibility of this Nation in the field of space exploration, the broad outlines of our long-range plan, and the underlying philosophy which influences NASA in the conduct of its many activities.

I believe that the space exploration program, with manned exploration of the moon and the planets, is the greatest challenge ever to face mankind.

Space has been the one environment so far inaccessible to man. With his successful conquest of the atmosphere, man's drive to fly higher and faster has led him to the edge of space. With increased understanding of, and control over, the mechanisms and materials of propulsion, it was only a matter of time before he would begin to explore the solar system.

It now seems as though all elements necessary to support of such an effort are available to us, provided the people of this country want the job done. And I believe they do.

The space age is upon us and the United States cannot afford to lag in space research and exploration even though the cost will be high.

If we accept this situation, we must then consider the desirable rate and scale of our space effort. Here, unfortunately, the choice is not completely in our hands. The Soviet Union is making impressive progress in this field.

As you well know, the U.S.S.R. is using its space activities for propaganda purposes to persuade the peoples of the so-called uncommitted nations, whose industrial development has been long delayed, that the Communist way of life is superior in all respects. Only as a secondary consideration does the search for new knowledge that will one day be useful to mankind, seem to motivate the people in control of the Soviet effort.

Mr. THOMAS. Let me interrupt. When Russia makes a little move superior to ours, why do we take it hook, line, and sinker? I doubt if half of those underdeveloped countries have heard of space. You can take this country and a good many people do not know who their Congressmen are.

I recall that several years ago we were considerably ahead of Russia in atomic energy. We did not moan and groan about that. I do not think anyone in the world paid any particular attention to it. Certainly, we did not get out and beat the drums and say that we have

this, that, and the other. Why do we suddenly reverse the situation and view Russia as sort of a prod pole for everything?

Dr. GLENNAN. I think, Mr. Chairman, I would rely somewhat on opinions of Mr. George Allen and Mr. Dulles as to the effects which have been encountered in countries other than our own, in countries other than those already committed to the Iron Curtain.

It seems clear that the Soviet Union has made effective propaganda of the successes they have had. And we have to admit they have had successes. They have used these successes in space research to convince the less well developed nations that the Soviet Union is aggressive, the best nation in all fields of science and technology. I think this—to use a Washington word—"image" has really been created.

Mr. THOMAS. I think the more outstanding "image," as far as Russia is concerned, is in the field of military strength. They can very easily tell the uncommitted people that they have 400 divisions under arms, and they can understand that, and the rest of the West has perhaps half that amount. They have 400 submarines and perhaps the West has 50 percent of that, so why shift the emphasis and use Russia as a prod pole in the field of space development, and play down the military angle? I think the uncommitted people can understand the use of military force much more than they can exploration around the moon. I just raise that point—why the shifting position?

Dr. GLENNAN. I think it is a good point to raise. I think the concern here is not so much a shift in our position but a reaction to the activities of the Soviet Union in this field, Mr. Thomas.

As you well put it, we have not found it necessary, or pleasing to us in areas where we are ahead to use this as an attempt to subjugate other countries because we are not in that business. Our reactions to their successes in space have been at times, I think, a little hysterical.

To me this is only one of the areas in which we are in competition with the Communist countries. But it happens to be a very glamorous area; it happens to be a very visible area.

Mr. THOMAS. I think you have used a very descriptive word when you used the word "glamorous."

Dr. GLENNAN. I do not think we can afford to ignore the very real impact that the Soviet Union is making in translating their success in the space field, in the minds of men everywhere, to strength in military things, strength in all the fields of science and technology, and ultimately into the strength of a nation in modern terms.

Mr. THOMAS. Somehow or the other we attempt to tie, or do tie, our activities in space with our military activities, and the military people do not see too much connection.

Dr. GLENNAN. Are you speaking of our military people?

Mr. THOMAS. Yes.

Mr. YATES. The President himself has said that, has he not?

Dr. GLENNAN. No; he has not said that, I think. What he has said is that the military will use space to accomplish a military end objective. They will use that medium just as they use the land or the sea, or the atmosphere. He says there is a program of space exploration for peaceful purposes, one that ought to turn up very useful knowledge and the application of that knowledge for peaceful purposes for the benefit of all mankind. These are the words of the act.

He says the attempt to make a single national program which puts together the military and the space exploration program is difficult, if not impossible, to do. With this I find myself in agreement.

Mr. THOMAS. Proceed.

Dr. GLENNAN. We cannot ignore the impact made the world over by Soviet successes in this field. Theirs have been spectacular and apparently successful experiments made possible largely because they possess rockets of higher thrust than those presently available in our program.

I am convinced that this Nation must meet the challenge of communism in whatever contest we find ourselves engaged. Space exploration is only one of the areas of competition. But it is the one with universal public appeal. It is the one in which they appear to the general public, to have a substantial edge.

I admit their superiority only in the area of propulsion. And I do not think they will maintain that superiority for long if we continue to build up our capability to undertake experiments that will lead to beneficial results and be convincing in the international arena as well.

It is important, therefore, that we lay out our own program—regardless of the direction the U.S.S.R. appears to be taking at any given moment—fund it adequately, and press forward with vigor and determination.

In my opinion, we are not going to achieve this superiority by excessive expenditures, by concentrating solely upon spectaculars, or by responding to the anguished cries of those who seem intent on making us believe, and are encouraging the rest of the world to believe, that we are so far behind that we may never forge ahead. In the first place, except in the impression created by an admittedly able effort involving the use of high-thrust, rocket-propelled launch vehicle systems, I don't admit to our being behind. Further, our plans and efforts to overcome our disability in the high-thrust rocket field are moving solidly ahead. This effort needs support—and the balance of the program needs adequate support if we are going to be able to utilize the higher thrust effectively when it becomes available to us.

Mr. Chairman, this is not a time for crash programs that lash out in many directions regardless of cost. This is a tough problem requiring sensible planning, adequate support, and continuous efforts to move toward solid goals. That is exactly what I propose to set forth in broad outline for you now—our first attempt at a plan looking 10 years into the future.

As you well know, research and development activities do not lend themselves to overly definitive planning so far ahead. They are fluid by their very nature and subject to continuing review. And, of course, what we accomplish next year—and 3 to 4 years from now—depends in large measure upon what we achieve this year.

Subject to these qualifications, however, I think the need for such a long-range program is obvious. Most of our programs presume a scheduled progress in launch vehicle and spacecraft development. We are dealing with leadtimes of 5 to 6 years—and longer. We must have objectives upon which to focus.

The first chart outlines the anticipated growth in spacecraft weight from year to year. "Spacecraft," incidentally, is a new term that we apply to that part of the vehicle which is to be placed into an earth

orbit or on a departure trajectory from the earth. The term includes the propulsion, attitude controls, and guidance units for maneuvering the spacecraft as well as the instrumentation for the experiments to be undertaken.

For comparative purposes, the chart measures spacecraft weight that can be projected into a low altitude earth orbit of about 300 miles.

In the early years our increasing capabilities will come about through use of the THOR-AGENA B, ATLAS-AGENA B, and ATLAS-CENTAUR.

In the 1963–67 time period, the SATURN first stage and successively improved upper stages using liquid hydrogen-liquid oxygen will account for our increased capability.

I would now like to consider our projected launch schedule which is illustrated in the next chart.

You will note that by fiscal year 1962 and beyond the present variety of first stage launch vehicle types will be reduced to one solid propellant rocket, the SCOUT, and three liquid propellant rockets—the THOR, ATLAS, and SATURN.

The AGENA B and CENTAUR will become our utility second stages until larger, high-energy upper stages come into use on SATURN in the fiscal year 1965 and beyond.

Through restriction of vehicle types, and more intensive experience with each, we expect to achieve long-needed reliability.

Beyond SATURN, the use of chemical fuels would lead us to a vehicle concept known as NOVA, with four to six times the SATURN thrust based upon use of the F–1, 1,500,000-pound single-chamber engine. Development testing on NOVA would occur in the 1968 time period.

The next chart deals with NASA's mission target dates. You will note that in the current year we are initiating tests of several vehicle development programs as well as the first orbital experiments in meteorology and communications. Also included are the first suborbital flights of the astronauts later this year.

Those are the flights which we have described before as utilizing the REDSTONE as the launch vehicle for the instrumented capsule, followed by a capsule carrying a primate, followed by manned flight. The astronaut is propelled some 125 miles into the air and down range about 200 miles. He will have perhaps 5 to 6 minutes of weightless flight.

Mr. OSTERTAG. Which one is the PIONEER V?

Dr. GLENNAN. PIONEER V is the flight we sent off on Friday and which is doing exceedingly well.

Mr. OSTERTAG. Is it shown on the chart?

Dr. GLENNAN. It is not shown on the chart. I should point out in response to your question, Mr. Ostertag, that this listing on the chart shows the highlights—the tough experiments we hope to do in the time period shown. It is not intended by any means to be a total listing of our program. It would take 15 of those charts to do that.

In calendar year 1961 we will be working toward the launching of an advanced lunar impact vehicle and initiation of CENTAUR flight tests. If all goes as planned in Project MERCURY, the first manned orbital flight will take place in calendar 1961.

From this point on, the major milestones in the 10-year plan include a comprehensive exploration program of the moon and the near

planets, and development of the SATURN vehicle to provide preliminary data leading toward manned lunar flight beyond 1970.

Such are the major objectives of NASA as we now see them. We are concentrating upon lunar experiments for many reasons. The moon is a scientific object of great interest; it may hold many keys to the origin of the earth. Furthermore, the lunar distance will provide us with the experience to attempt interplanetary flights later on. In short, we will be able to perfect our communications, guidance, and propulsion systems with a lunar target.

The program for which we are requesting $915 million in fiscal 1961 will assure steady progress toward the goals just delineated. It is a program calculated to yield significant results in the fields of science and technology, results which must certainly strengthen the Nation's position of international leadership. It is a program which we will carry out with due regard for an operating philosophy which combines the following elements; I consider these to be important:

(1) A recognition of the vital role to be played by the success or failure of this program in maintaining the posture of this Nation as a leader of the free world. Leadership in space research and exploration has come to mean leadership in most areas of science and technology when viewed by the industrially underdeveloped nations.

(2) A recognition of the necessity for taking calculated risks in the dynamic development of this difficult new technology. Such a policy must not be pursued blindly just to meet dates set for political or other reasons. But the pace should be an extremely urgent one.

(3) A determination to use the authority established in the Space Act to encourage cooperative programs in space research with able scientists of other nations. The space exploration program is proving to be a natural vehicle for worldwide cooperation in such matters as tracking, communications, and meteorology.

(4) A determination to cooperate with, and provide support to, the Department of Defense. Each must surely benefit from the experience and findings of the other. Unnecessary duplication must be avoided.

(5) A recognition of the importance of using competitive private industry to carry the major portion of NASA activities. Avoidance of additions to the Government's payroll will result in the strengthening and broadening of our industrial base for research, development, and operations in space exploration.

(6) A recognition that, while adhering to the concept of open discussion of the unclassified portion of our activities, it is important that we first accomplish our objectives and only then talk about them. Difficult as this may be, we will strive to achieve a continually increasing degree of acceptance of this philosophy. Unlike a dictatorship, however, we will continue to announce our failures as well as our successes.

I want to express my appreciation to the committee for its alert, continuing interest in our program.

With me today are several of my associates who will also discuss the fiscal 1961 request. They are prepared, as I am, to answer any questions you may have.

I have the biographies of several of my staff who are here today that I would like to present for the record.

(The biographies referred to follow:)

T. Keith Glennan, Administrator

T. (Thomas) Keith Glennan is the first Administrator of the National Aeronautics and Space Administration, established October 1, 1958, under the National Aeronautics and Space Act of 1958.

As Administrator, Dr. Glennan heads a staff of scientists, engineers, technicians, and other employees engaged in research and development in aeronautics and space matters. In this position he is a member of the President's National Aeronautics and Space Council.

Glennan is president on leave of the Case Institute of Technology, Cleveland, Ohio, which he has headed since 1947.

Born in Enderlin, N. Dak., in 1905, Dr. Glennan earned a degree in electrical engineering from the Sheffield Scientific School of Yale University in 1927.

Following graduation, Glennan became associated with the newly developed sound motion picture industry, and later became assistant general service superintendent for Electrical Research Products Co., a subsidiary of Western Electric Co. During his career he was studio manager of Paramount Pictures, Inc., and Samuel Goldwyn Studios, and was briefly on the staff of Vega Airplane Corp.

Glennan joined the Columbia University Division of War Research in 1942, serving through the war, first as Administrator and then as Director of the U.S. Navy's Underwater Sound Laboratories at New London, Conn. For his work he was awarded the Medal of Merit.

At the end of World War II, Dr. Glennan became an executive of Ansco, Binghamton, N.Y. From this position he was called to the presidency of Case. During his 11-year administration, Case rose from a primarily local institution to rank with the top engineering schools in the Nation. From October 1950, to November 1952, concurrent with his Case presidency, he served as a member of the Atomic Energy Commission.

Dr. Glennan has been very active in national and civic affairs. He was Chairman of the Board of the Institute for Defense Analysis, on the Board of the National Science Foundation, and the Council on Financial Aid to Education. In Cleveland he took an important part in many civic activities.

Glennan is a fellow of the American Academy of Arts and Sciences, and a member of Sigma Xi, Tau Beta Phi, and Chi Phi. He has been awarded several honorary degrees of doctor of science.

Dr. and Mrs. Glennan (the former Ruth Haslup Adams) have four children. They live at 4740 Connecticut Avenue NW., Washington, D.C.

Hugh Latimer Dryden, Deputy Administrator

Hugh Latimer Dryden was appointed Deputy Administrator of the National Aeronautics and Space Administration on August 8, 1958. Before that date he was for 11 years Director of the National Advisory Committee for Aeronautics. As such he had charge of the Nation's flight research establishment with nearly 8,000 employees, 3 large laboratories, and 2 field stations. The NACA provided scientific information useful in the design of aircraft, missiles, and space craft. Its organization and functions were absorbed within the NASA as of September 30, 1958.

Dr. Dryden's career has been in aeronautics and related sciences, and he has made many technical contributions by his research in high speed aerodynamics, fluid mechanics, and acoustics. He has published more than 100 technical papers.

Born July 2, 1898, in Pocomoke City, Md., Dr. Dryden was reared in Baltimore. He was an honor students at Johns Hopkins University, completing the 4-year arts course in 3 years. While continuing his studies at the graduate school of the same university, he conducted research in fluid mechanics at the National Bureau of Standards. He was granted the degree of doctor of philosophy in 1919.

While he was head of the Bureau of Standards' Aerodynamics Section from 1920 to 1934 he made some of the earliest studies of airfoil characteristics near the speed of sound. He also did pioneering work on turbulence and the mechanics of the boundary layer. He was promoted to Chief of the Bureau's Mechanics and Sound Division in 1934, to Assistant Director in January 1946, and to Associate Director 6 months later.

Results of his work dealing with the properties of airfoils at high speeds, wind-tunnel investigations, boundary layer and turbulence, noise suppression,

and other aeronautical matters have been published in professional and trade journals.

Dr. Dryden was the first American to be selected to deliver, in 1938, the Wright Brothers lecture before the Institute of the Aeronautics Sciences. He is an honorary fellow of the institute and served as its president in 1943. In 1956 he was named an honorary fellow of the Royal Aeronautical Society.

For more than 2 decades he has served on numerous scientific advisory groups. In World War II he headed the research project which developed the first American combat missile, the BAT, and served on committees advising the Joint Chiefs of Staff, NACA, Army Ordnance Department, and Army Air Force. In 1945 he was appointed Deputy Scientific Director of the AAF Scientific Advisory Group and toured Europe studying foreign scientific work in aeronautics and guided missiles.

He is now a member of numerous Government scientific advisory committees serving the President, the Department of Defense, the Air Force, the Army and other Federal agencies, and the North Atlantic Treaty Alliance. Since 1955 he has been home secretary of the National Academy of Sciences.

He is a member of more than a dozen American and international professional societies and holds seven honorary degrees. He lives with his family in suburban Washington.

Richard E. Horner, Associate Administrator

Richard E. Horner was appointed Associate Administrator of the National Aeronautics and Space Administration on June 1, 1959. Under T. Keith Glennan, Administrator, and Hugh L. Dryden, Deputy Administrator, he is responsible for the general management of NASA's operations which include laboratories, research centers, rocket testing and launching facilities, and a world network of tracking stations.

To accept the NASA position, Horner resigned as Assistant Secretary of the Air Force for Research and Development, a position he had held since July 8, 1957. He had been Acting Assistant Secretary since February 1956.

Born October 24, 1917, in Wrenshall, Minn., he is a graduate of the University of Minnesota, where he received a bachelor of science degree in aeronautical engineering in 1940. He received a master's degree from Princeton University in 1947.

Horner was commissioned a second lieutenant, Army Air Corps, in 1940 and served in World War II as a pilot with tactical units in the corps and with the Air Material Command. He was awarded the Silver Star, the Air Medal with four clusters, and the Presidential Unit Citation. In 1949, he was released from active duty with the rank of colonel, U.S. Air Force.

He was employed in a civilian capacity as aeronautical development engineer at the Air Force Flight Test Center, Edwards Air Force Base, Calif. In 1952, he became technical director of the test center. In 1955, he was named Deputy for Requirements to the Assistant Secretary of the Air Force for Research and Development, holding that position until his appointment as Acting Assistant Secretary.

Horner is married to the former Jean Margaret Hodgson of Waseca, Minn. They have two children, Richard James and Judith Rae, and live at 3612 North Peary Street, Arlington, Va.

Maj. Gen. Don R. Ostrander, USAF, Director, Launch Vehicles Programs

Maj. Gen. Don R. Ostrander was appointed NASA Director of Launch Vehicle Programs on December 16, 1959. On Air Force assignment to the civilian space agency, he is in charge of NASA booster development and rocket launching operations. Previously he was Deputy Director of the Advanced Research Projects Agency.

General Ostrander, 45, is a 1937 graduate of the U.S. Military Academy. Born in Stockbridge, Mich., he attended local schools and studied engineering at Western State College, Michigan, before entering West Point.

During World War II, he served as ordnance armament officer with the Eighth Air Force Interceptor Command in England. In this role he helped modify the P–38 airplane to accommodate a Norden bombsight and bombardier. His decorations include the Legion of Merit with cluster.

He has held a variety of administrative posts within the Air Force Air Research and Development Command going back to 1951, working on weapons sys-

tems and missile programs. He moved into the ARPA post after more than a year's duty as assistant to the NATO Assistant Secretary General for guided missile production in Paris.

He was promoted to brigadier general in October 1954 and received his second star in March 1958.

General and Mrs. Ostrander (the former Frances Dunn) and their three children live in Alexandria, Va.

Abe Silverstein, Director of Space Flight Programs

Abe Silverstein is Director of Space Flight Programs at NASA headquarters in Washington, D.C. Before the NASA was established on October 1, 1958, he was Associate Director of the Lewis Flight Propulsion Laboratory, Cleveland, Ohio, a research center of the National Advisory Committee for Aeronautics, which formed the nucleus of the NASA.

Silverstein directs those NASA programs charged with mission planning, payload design and development, and in-flight research and operation. Development programs under his direction include space probes and manned and unmanned satellite systems.

Silverstein is a native of Terre Haute, Ind., where he attended local grammar and high schools. He earned a bachelor of science in mechanical engineering degree in 1929, and a mechanical engineering professional degree in 1934 from Rose Polytechnic Institute. He was awarded an honorary doctorate by Case Institute of Technology in 1958.

Silverstein joined the National Advisory Committee for Aeronautics in 1929, and soon after helped design the full-scale wind tunnel at the Langley Aeronautical Laboratory. He later was placed in charge of this facility, and directed research which increased the high-speed performance of most of the combat aircraft of World War II. This work was recognized as a major factor in gaining U.S. air superiority during the war.

In 1943 he was transferred to the Lewis Laboratory at Cleveland to select and train a staff which he directed in research at the altitude wind tunnel. These investigations led to significant improvements in both reciprocating and early turbojet aircraft engines. He also pioneered with large-scale ramjet engines now used on certain missiles.

At the end of World War II Silverstein was directing the work at several major research facilities at Lewis. He directed the erection of the $9 million NACA 8- by 6-foot supersonic wind tunnel, first operated in 1949, and the $33 million NACA 10- by 10-foot supersonic wind tunnel completed in 1956. These facilities, the largest wind tunnels of their kind in the world, have greatly accelerated the development of supersonic aircraft. In 1952 he was appointed Associate Director of the Lewis Laboratory, a post he held until he was named to the headquarters staff of the NASA.

Silverstein was a member of several NACA committees and subcommittees including Committee on Aerodynamics, 1946–47; Subcommittee on Self-Propelled Guided Missiles, 1945–47; Subcommittee on Internal Flow, 1947; Subcommittee on High-Speed Aerodynamics, 1945–57; Committee on Powerplants for Aircraft, 1951–57; and the Special Committee on Space Technology, 1958.

He served as chairman of the Cleveland section of the Institute of Aeronautical Sciences, 1946–47. He was a member of the committee on arrangements for the joint meeting of the Institute of the Aeronautical Sciences and the Royal Aeronautical Society, held in New York City in 1949. The Assistant Secretary of Defense for Research and Development appointed him a member of the Technical Advisory Panel on Aeronautics for the year 1955, and Chairman of the Ad Hoc Working Group on Rockets for 1956. He was a member of the Scientific Advisory Board of the Chief of Staff, U.S. Air Force for 1956 and 1957, and Chairman of the OASD Technical Advisory Panel on Aeronautics, Ad Hoc Group on Propulsion for Aircraft and Missiles. He was a member of the Assistant Secretary of Defense's Steering Group of the Advisory Panel on Aeronautics for 1958.

Silverstein was American representative to the joint meeting of the Institute of the Aeronautical Sciences and the Royal Aeronautical Society, in London, in 1947. He delivered the annual Wright brothers lecture before the IAS in 1949.

He is a member of Tau Beta Pi, and a fellow of the Institute of the Aeronautical Sciences.

Silverstein, his wife Marion, and their three children live at 7205 Rollingwood Drive, Chevy Chase, Md.

Ira H. Abbott, Director of Advanced Research Programs

Ira H. Abbott was appointed Director of Advanced Research Programs July 1, 1959. His office is charged with advanced research in aeronautics and space. He was named Deputy Director of the office the previous March.

Born July 18, 1906, at Wolfeboro, N.H., Abbott was graduated from Newburyport, Mass., high school. He received a bachelor of science degree from Massachusetts Institute of Technology in 1929.

Following his graduation, he began his 29-year career with the National Advisory Committee for Aeronautics, the predecessor of the NASA, as a junior aeronautical engineer at Langley Aeronautical Laboratory, Virginia. He was promoted to senior aeronautical engineer in 1941, and named Langley's Assistant Chief of the Full-Scale Research Division in 1944. The following year he became Assistant Chief of the Research Department.

Abbott was transferred to NACA headquarters, in Washington, in 1948, as aeronautical consultant and was named Assistant Director of Research (Aerodynamics) in 1950. When the NASA was established October 1, 1958, he was appointed Assistant Director of Research for Aerodynamics and Flight Mechanics.

He is a member of the Civilian-Military Liaison Committee, and a fellow of the Institute of the Aeronautical Sciences. From 1957 to 1958 Abbott was Chairman of the Wind Tunnel Panel of NATO's Advisory Group on Aeronautical Research and Development.

Mr. and Mrs. Abbott (the former Martha Leola Streeter) have three children and live at 3704 Bradley Lane, Chevy Chase, Md.

Albert F. Siepert, Director of Business Administration

Albert F. Siepert has been Director of Business Administration since the National Aeronautics and Space Administration was established in October 1958. During the previous 10 years he was executive officer of the National Institutes of Health.

Born in Peoria, Ill., in 1915, Siepert received a bachelor of arts degree from Bradley University in 1936.

After graduation, Siepert became one of the first Government "interns" (trainees) under the auspices of the National Institute of Public Affairs. He served his internship with the Farm Credit Administration, and has since held administrative posts with the Home Owners Loan Corporation, the Alien Property Custodian, and the Bureau of State Services of the U.S. Public Health Service.

Named executive officer of the National Institutes of Health in 1948, Siepert had a key role in a thoroughgoing reorganization and expansion of the Institutes during the initial years of his NIH appointment. He received the Arthur Flemming Award in 1950 for his contribution. In 1955 he received the Department of Health, Education, and Welfare's Distinguish Service Award for his administrative leadership.

Mr. and Mrs. Siepert and their two children live at 7209 Honeywell Lane, Bethesda, Md.

Ralph E. Ulmer, Budget Officer

Ralph E. Ulmer has been budget officer of the National Aeronautics and Space Administration and the National Advisory Committee for Aeronautics, the predecessor of the NASA, since 1950.

Born in Toledo, Ohio, in 1917, he earned a bachelor of science degree in aeronautical engineering from the University of Michigan in 1938.

Ulmer joined the NACA as a junior aeronautical engineer at the Langley Aeronautical Laboratory, Hampton, Va., after graduation in 1938. He specialized in propeller research before becoming an assistant to the administrative officer.

In 1940, Ulmer was transferred to NACA's Washington headquarters where he became assistant to the executive officer. In 1950 he was appointed budget officer. He is a member of Sigma Xi.

Mr. and Mrs. Ulmer and their two children live at 5140 Tilden Street NW., Washington, D.C.

JAMES P. GLEASON, ASSISTANT ADMINISTRATOR FOR CONGRESSIONAL RELATIONS

Mr. Gleason is a native of Cleveland, Ohio, where he attended local grammar and high schools. After 3 years (1942 to 1945) in the U.S. Army, he entered Georgetown University and was awarded a bachelor of social science degree in 1948. During the next 2 years, he attended Georgetown's School of Law, and served as a staff member of the school's Law Journal. He received an LL.B in 1950.

From 1951 to 1953, he was legislative assistant to Richard M. Nixon, Senator from California at that time. From 1953 until recently, Mr. Gleason was administrative assistant to Senator Knowland.

Mr. Gleason is a member of the Maryland and District of Columbia bars.

He is married to the former Miss Georgette E. Smith. Mr. and Mrs. Gleason have three children attending grammar school: Millicent, 10, Patricia, 8, and James, 6. They have one other daughter, Mary, 3. The Gleason family lives at 513 Gilmoure Drive, Silver Spring, Md.

WILLIAM H. PICKERING, DIRECTOR, NASA-CAL TECH JET PROPULSION LABORATORY

William H. (Hayward) Pickering is director of the jet propulsion laboratory, Pasadena, Calif., which is operated by the California Institute of Technology under contract to the National Aeronautics and Space Administration.

Dr. Pickering directs the research and development work of about 2,300 scientists, engineers, and supporting staff, in the fields of rocket propellants, and in electronics, communications, and guidance used in space technology.

Dr. Pickering is a native of Wellington, New Zealand. He earned a bachelor of science degree in 1932, a master of science degree in 1933, and a doctorate in physics in 1936 at California Institute of Technology. He became a citizen of the United States in February 1941.

He has been a member of the faculty of Cal Tech since 1932 and was appointed professor of electrical engineering in 1946. He has been associated with the jet propulsion laboratory since 1944. He later was in charge of electronics work and in 1950 was given the responsibility for the CORPORAL missile program at JPL. In 1954, he was named director of the laboratory.

Dr. Pickering's fields of research have included cosmic rays, telemetering from balloons and rockets, microwave propagation, development of cosmic ray radiosonde, and missile guidance problems.

His memberships have included the Scientific Advisory Board of the U.S. Air Force, a number of other committees of the Department of Defense, and the U.S. National Committee's Technical Panel on the Earth Satellite Program and its working group on tracking and computation. He is a fellow of the Institute of Radio Engineers, the American Rocket Society, and a member of the American Institute of Electrical Engineers.

His awards include the 1957 James Wyld Memorial of the American Rocket Society; a special award by the Los Angeles Chamber of Commerce in 1958 for creative achievements; and a scientific achievement award from the Greater Los Angeles chapter of the association of the U.S. Army in 1958.

Dr. Pickering is married to the former Muriel Bowler. Dr. and Mrs. Pickering and their children, William B., 19, and Anne E., 16, live at 2514 Highland Avenue, Altadena, Calif.

HARRY J. GOETT, DIRECTOR, GODDARD SPACE FLIGHT CENTER

Beginnig in 1948, Harry J. Goett directed some of the first space research of the NASA's predecessor agency, the National Advisory Committee for Aeronautics, using a special wind tunnel to reproduce low densities found at extreme altitudes. He has been engaged in research in aerodynamics and the operating problem of flight more than 23 years. Since NASA was established, he has provided technical liaison for the Agency's West Coast satellite and space probe activities, including the PIONEER series, two of which were put into orbit around the sun.

Goett was chairman of a technical review team which contributed improvements to rocket vehicle systems used by NASA. He is a member of the Research Advisory Committee on Control, Guidance, and Navigation, and Research Steering Committee on Manned Space Flight, and head of the astronomical satellite team of the NASA Ames Research Center.

In his career with NACA, Goett for many years was a member of the Subcommittee on Automatic Stabilization and Control, and of the working group on instrumentation of the Special Committee on Space Technology which was

formed in 1957. He comes to his new duties from the Ames Research Center, where he has been chief of the Full Scale and Flight Research Division since 1948.

The Goddard Center organization will be composed of three major research and development groups under assistant directors. These are space sciences and satellite applications, under John W. Townsend, Jr.; tracking and data systems, under John T. Mengel; and manned satellites, under Robert R. Gilruth. Michael J. Vaccaro is business manager.

Born November 14, 1910, in New York City, Goett attended elementary and high schools there. He was graduated from Holy Cross College in 1931 with bachelor of science degree, and 2 years later earned the degree of aeronautical engineer at New York University. He took additional studies of law at Fordham University.

From 1933 to 1935, he supervised machinery installations for the Waterbury Rope Co., New York City, then was employed by the Sumerill Tubing Co., and the Douglas Aircraft Co. for a short period. He joined the research staff of NACA's Langley Aeronautical Laboratory in July 1936. He was transferred in July 1940 to Moffett Field, Calif., where the Ames Laboratory was under construction.

At Ames, Goett first was engaged in design of wind tunnel model and support systems. He became head of the laboratory's 7 by 10 foot wind tunnels, conducting research on stability and control qualities of airplanes. In World War II, he was advanced to head the 40 by 80 foot wind tunnel (world's largest), supervising the general research program for improving American airplanes. He was promoted again in 1944 to Assistant Chief of the Full Scale and Flight Research Division, where he became Chief 4 years later.

His research work has covered a broad range of problems in aerodynamics and operations, including atmosphere reentry, aerodynamic heating, low speed and vertical takeoff aircraft, stability and control, in-flight studies of boundary layer control, automatic flight and jet engine thrust reversers. Under his direction, the Division conducted successful research on a thrust reverser and flight approach control for jet airplanes. Goett has written or coauthored a dozen technical reports.

He and his wife, the former Barbara Alexander, are parents of two boys and two girls. They now live in Los Altos, Calif.

Werhner von Braun, Director, Development Operations Division, Army Ballistic Missile Agency

Werhner von Braun was born in Wirsitz Germany, in 1912. Because his father was a government official who moved about Germany often, he gained his early education in various grammar and high schools from 1918 to 1930.

In 1932, Dr. von Braun received his bachelor's degree in aircraft engineering from the Institute of Technology at Zurich, Switzerland. Two years later, he earned his Ph. D. in physics from the University of Berlin.

From 1932, when he joined the German ordnance department, until 1937, Dr. von Braun was chief of the liquid fuel rocket development at Kummersdorf, approximately 50 miles south of Berlin. In 1937, the Kummersdorf rocket development was transferred to a newly formed rocket center, Peenemuende, of which Dr. von Braun became the technical director. The center's main mission was the development of the V–2 rocket. Other work included the development of an antiaircraft missile, the Wasserfall, and liquid fuel JATO units for heavy bombers and fighter aircraft.

In 1945, Dr. von Braun came to the United States with six other scientists under contract to the U.S. Army Ordnance Corps. His first assignment was as adviser for V–2 high-altitude research firings at White Sands Proving Ground, N. Mex. Later he was made project director for a guided missile development unit at Fort Bliss, Tex., where he was joined by about 120 scientists and technicians who had worked with him at Peenemuenda.

From 1950 to 1956, Dr. von Braun was Chief of the Guided Missile Development Division at Redstone Arsenal, Huntsville, Ala. Since 1956 he has been Director of Development Operations Division, Army Ballistic Missile Agency, Huntsville.

Dr. von Braun received his U.S. citizenship in May 1955.

STAFFING REQUIREMENTS

Mr. THOMAS. That was a nice statement and right to the point. Generally, what are your programs for the next 2 years? Let us stay with 2 rather than 10. You come in here with a rather modest request for only a 6,350 increase in personnel. What will it be next year?

Dr. GLENNAN. I can speak to that this way: A year ago I think I said it was my intent that we would not add people to the Federal payroll beyond those we deemed absolutely necessary to this program. We have added a lot this year, but most of them by transfer from other agencies of Government.

I think, Mr. Chairman, in the 18 months that we have been in existence we have added to the Federal payroll about 1,500 new persons. All the rest have come to us from other agencies as programs have been transferred.

With the acquisition of the Von Braun operation, we find ourselves with a total on-board complement as of June 30 of this year of something in the neighborhood of 16,000 people. There is no necessity for further major additions of new laboratory facilities and people, in my opinion.

Mr. THOMAS. Beyond what is in this budget?

Dr. GLENNAN. In speaking of that, I am speaking of completely new laboratories; not the normal additions to existing laboratories which are required by reason of changes in programs, new information we discover throughout the years and that sort of thing. It is my opinion that with the complement of laboratories which we presently have—the five large Government-owned and civil-service-personnel-operated laboratories—and with the one contract laboratory, we have experienced the maximum growth we are going to have.

Mr. THOMAS. Your Jet Propulsion Laboratory is not included in your 16,350 personnel.

Dr. GLENNAN. I spoke of that as a contract laboratory which brings our total personnel to about 19,000.

Mr. THOMAS. How many did you take over from the Huntsville installation in Alabama?

Dr. GLENNAN. The complement will be 6,689 for the coming year.

Mr. THOMAS. That is the takeover figure?

Dr. GLENNAN. The takeover figure is 5,500 civil-service positions. The additional 1,189, if my arithmetic is correct, are contractor-support personnel.

We have a going situation, Mr. Thomas. We are requiring them to stay within that personnel ceiling as we add to their workload. Our ultimate aim there is to have a self-contained laboratory of 5,500 civil-service positions, in which positions one would find—in the neighborhood of 4,300, perhaps a few more—in the scientific area and 1,200 supporting administrative personnel.

Mr. THOMAS. As far as your laboratories are concerned, your personnel figure, if I understand you correctly, in the next year or two will not increase and neither will your construction and development program other than some modernization features?

Dr. GLENNAN. My guess is that the personnel in our next budget will not increase measurably. I am sure there will be some increases which one normally expects in these kinds of operations. Mr. Ulmer

reminds me in our planning for the Goddard Center, which I believe is to be at the level of 2,000 for the fiscal year 1961, we have set a tentative figure of 2,400 for 1962, so we would expect some increase in staffing to be requested.

With respect to the construction and equipment, I think this is a matter one has to look at year by year. Undoubtedly, on our older campuses, if you will—Langley, Lewis, and Ames Research Centers, there will be further modernization of equipment. Undoubtedly as we move forward in this dynamic business that we are in, we are going to find the need for additional environmental test facilities, probably larger in capacity than we presently have, and that type of thing.

As to major building improvements, I think one has to look at the needs every year. I would not want to completely close the door on this, but I think we are now in the period of our major facility expansion.

Mr. THOMAS. In looking over your construction, and maybe some sections of your research programs at Ames, Langley, and your Cleveland laboratory, your justifications clearly point out the equipment on board now is not suited in all respects, to say the least, for the new space program. I am just wondering what you have been doing with 9,000 personnel in those places? It looks to me like you should show a reduction there if the equipment is not suited for your program. I notice you have been wanting to increase them, and your construction program is going to require anywhere from 12 months to 36 months before you can get your equipment in there suited to your needs.

Dr. GLENNAN. There is plenty of equipment at those laboratories that is suited to the needs of the program as we presently have it—and many additional facilities partially suited. It is not a matter of having people sit around, Mr. Thomas.

Mr. THOMAS. What are they doing in this interim period? Here are three big installations that cost hundreds of millions of dollars set up for the aviation industry, or your might say dominated by the aviation industry.

Dr. GLENNAN. Much of the equipment on hand—the wind-tunnel equipment, for example—is also usable in this field. There is not a sharp line of demarkation betwen the aeronautics and missile field and the space field in research. There is a continuous spectrum here, and we are moving consciously from one portion of that spectrum to the other.

Mr. THOMAS. Why have we not been operating in this field for the last 10 years, if you want to make it that simple?

Dr. DRYDEN. May I give an illustration? The Project MERCURY capsule has to return to the atmosphere through the entire speed range—from satellite speed all the way down to the speed for landing in the ocean with a parachute. Work in connection with Project MERCURY has been in a great many of our wind tunnels of all capacities. We have been making the conversion into space for the past 5 years. You have provided the funds for facilities suitable for very high speed investigations, and for other specialized facilities. This transition is not something that comes up on a certain date, and all of a sudden you are in space. This transition has been going on for quite a long time, and there has been no lack of anything to do.

Every vehicle we fire has to start from zero speed on the ground and go up through the atmosphere into space. It has to go up in a stable manner just as an aeroplane. We cannot let it wobble all over the place, so we must do these ground tests to provide greater assurance of success. It may be necessary because of the arrangement of components to change the shape of the front end of the satellite vehicle. We must then predict design loads for them just as design loads are required to permit the structural design of aeroplanes. It is quite true that the intensity of operation of some of the equipment is changing. We are closing up some of the facilities that are no longer useful and transferring some people to more intensive operation of other facilities.

I think you have been familiar with the fact that through the years some of our equipment is operated two and three shifts, some one shift, and some only when some particular investigation is needed. There have been changes of assignment of personnel between various forms of equipment as the work changed and some of the equipment is being mothballed. We have to have subsonic wind tunnels for space vehicles as well as for aircraft and missiles.

Mr. THOMAS. I wonder if the budget officer would be good enough to put his finger on the cost of electric current down at Huntsville. You have chased me over 150 pages of the justifications for the last 3 days, and I have not been able to catch that figure yet. You do set it out for the other installations.

Dr. DRYDEN. Huntsville legally comes to us today, and the formal transfer will take place July 1 as far as fiscal operations are concerned. It has been difficult to get the kind of detailed information you want. The operation under NASA will be quite a bit different than the operation under the Army system.

Mr. OSTERTAG. You have no official records of costs up to now? In other words, that has been under the jurisdiction of the Army and you have no way of showing it?

Dr. DRYDEN. We will be glad to put the figure in the record, Mr. Thomas.

Mr. THOMAS. I would not be a bit surprised if it is not in there some place. All I say is I chased it for 3 days and did not find it. It is going to be a lesser figure than at the other installations. I was curious to see what it was.

Dr. GLENNAN. I would like, if I may, to avoid leaving any impression this is a static business because it is not. No research and development business is static.

Mr. THOMAS. That is an understatement, but proceed.

Dr. GLENNAN. The period of our very rapid growth and expansion seems to me, from my short-range viewpoint, to be fairly well behind us. One should be looking at this in the future as an aggressive, developing operation, but without the explosive nature which has been a characteristic of the last 18 months.

Dr. SILVERSTEIN. Another example along the lines Dr. Dryden mentioned regarding thework of our advanced research centers—you have intimate knowledge of the work done at Lewis in advanced propulsion.

Mr. THOMAS. You have been there, Doctor?

Dr. SILVERSTEIN. Yes, some 15 years.

Mr. THOMAS. The record ought to show the doctor was one of the leading lights there, I can testify, for 10 years. You say 15?

Dr. SILVERSTEIN. Yes. Some 6 years ago in our advanced research, we began work on hydrogen-oxygen as propellants for rockets, getting into the advanced phases of the work, finding out how these fuels reacted in combustion chambers and studying cooling problems relating to them. That work has continued at Lewis during that period of time, moving into larger engine sizes, and moving from basic research fields into the applied fields. When we were ready for the propulsion system for CENTAUR, which is the first of our vehicles that uses hydrogen-oxygen, there was a very substantial background of basic information that was in hand and the Pratt-Whitney Co. was able to borrow from it in building the first hydrogen-oxygen engine. Now we find the SATURN, which is our most important major vehicle for the future, is coming along and is also able to exploit the use of this fuel, largely because there has been a background established.

Taking another case, in the field of electric propulsion, which is a thing for the future now, as we look ahead in our programs at this long-range program that Dr. Dryden has laid out, we see very definitely the need for electric propulsion in the program.

NUCLEAR REACTOR

Mr. THOMAS. While you are mentioning that, I raised the question in my own mind last night whether or not $12 million was thrown away in Cleveland on that atomic energy setup that you and our distinguished friend advocated so strongly 6 years ago. That is just about thrown out of the window; is it not?

Dr. SILVERSTEIN. May I discuss that?

Mr. THOMAS. I hope you will.

Dr. SILVERSTEIN. In the electric propulsion field, we started this work some 4 or 5 years ago, recognizing in our space activities that we undertake in the future—and this was before space was commonly accepted—that these types of engines would be needed, and we started small experimental research units working on the problem—not large but small. This work was kept in progress, and we have moved steadily forward in establishing the basic fundamentals of this field of propulsion.

Now, in our going work, we will move to somewhat larger engine sizes, continuing to study the basic elements in the field. These data will then be used by industry to provide actual hardware as a basis for the creation of these systems.

From the standpoint of the nuclear systems, we saw some time ago nuclear power would be important in our advanced propulsion field, so we started to develop the facilities required, the reactor at Plum Brook. We see there is a tremendous problem here of the materials to be used in these reactors, materials which have to be able to live in an environment of radiation and at the same time in an environment of high temperature and be cooled in a fashion we have not required of materials before, that is, in the presence of liquid metals, corrosion, erosion, and these subjects.

This work is underway. Our facility is planning to start soon, and we will conduct a basic research program, leading up to a sound expenditure at a later time for actual engine hardware.

Mr. THOMAS. You are going to spend $6, $8, or $10 million for the laboratory on liquid metals. What has that to do with your atomic energy reactor that you spent $12 million on?

Dr. SILVERSTEIN. The problem of research in liquid metals is a good case in point.

Mr. THOMAS. You know we have been working on an atomic reactor for an airplane for the past 9 years now. We have thrown away about $12 million out at your place on this reactor in duplication, duplication, duplication.

Dr. SILVERSTEIN. I think not, sir, from the standpoint of duplication. The work we are doing is fundamental in character leading to a situation where we will not throw money away when we go into manufacture. This has been the particular art of NACA before and currently to develop the basic information required in the field so when you go into actual production with a unit the solid information is available from which to create hardware that works.

Dr. GLENNAN. I think that we ought to ask Dr. Dryden to enlarge on this since he supported it strongly when it was initiated.

Dr. DRYDEN. I might try to answer that, Mr. Chairman.

The effort in Ohio which you described is addressed at attempting to build a reactor to put in an airplane to propel it. The reactor at Plumbrook is a materials test reactor of more or less conventional design. It provides conditions of high radiation flux so that research investigations may be made on materials and components which could be used in a flight reactor in an airplane or in a rocket. This, of course, is of great interest to us in the nuclear rocket which offers a lot of promise for use in the upper stages of rocket vehicles when it is developed.

You have been reading about project ROVER, which is a project being carried on in cooperation between the AEC and ourselves. AEC is developing the actual reactor for use in rockets and have the responsibility for the rest of the rocket—for the pumps which pump the liquid hydrogen through it and for the control system which controls both the reactor and the vehicle as a unit and for the vehicle itself. We have some investigations which must be made in connection with that part of the rocket. For example, very little is known about the effect of radiation on materials at the temperatures of liquid hydrogen, and perhaps the earliest job to be done in our reactor is this study of the effect of radiation on materials at liquid hydrogen temperatures. Project ROVER will reach the stage of ground tests of a bread-board engine on a test bed sometime in 1963—in that general period—and it will be possible to have an operating nuclear rocket engine and to do test flights and other operational tests at a later date.

Dr. GLENNAN. Mr. Thomas, in an effort to try and give you and the committee a fairly broad but briefly stated picture of the total operation, I had hoped you would be willing to hear Dr. Dryden discuss the scientific and technological results and plans as well as the results of the past year's activity and the plans for the immediate future, with Mr. Horner following him and giving you a picture of his part of the program.

Mr. THOMAS. Is Mr. Horner a scientist?

Dr. GLENNAN. Mr. Horner is formerly the assistant Secretary of the Air Force for Research and Development.

Mr. THOMAS. Is he a businessman?

Dr. GLENNAN. No, sir.

Mr. THOMAS. I looked over his statement this morning and it looks like he has been working for the Government since he got out of college. Now you have him spending $915 million.

Dr. GLENNAN. I think he is going very well at it.

Mr. THOMAS. I imagine he is spending it pretty fast. I do not know how well. Like General Motors, Henry Ford, United States Steel and all the big corporations, they pick their managers——

Dr. GLENNAN. If you will change the way in which the Government provides for the support of this kind of program I think you may get different kinds of managers. In the meantime we are going to do just the very best we can.

Mr. THOMAS. You picked him. Did anyone wish him off on you?

Dr. GLENNAN. I would not want anyone in this job except Mr. Horner at present.

Mr. THOMAS. He is going to spend $915 million and never had any business experience on his own account?

Dr. GLENNAN. In the maelstrom in which we work, Mr. Thomas——

Mr. THOMAS. If you want to whitewash it, go ahead.

Dr. GLENNAN. I am not intending to whitewash it. I am simply trying to state the facts.

Dr. DRYDEN. He was involved in important major programs in the Air Force.

Mr. THOMAS. Without any prior business experience?

Dr. DRYDEN. He had a lot of business experience in the Government. If you mean private business, the answer is "No." He was a pilot and an aeronautical engineer.

Dr. GLENNAN. In other words, he had to use the things we are trying to deal with.

Mr. THOMAS. You are dealing with dollars and cents.

Dr. GLENNAN. We would like to go on with General Ostrander, Dr. Silverstein, and Mr. Abbott on the launch vehicle programs and the space flight programs as well as the research programs. This should not take long.

Dr. DRYDEN. Mr. Chairman, I would like to talk from a few charts, giving you a report in very general terms on what we have done with the money last year.

Mr. THOMAS. We want Mr. Horner to be thinking up a good excuse for the statement he made the other day to the effect that a reduction of $6 million delayed one of these vehicles 18 months to 36 months.

We want him to have a little advance notice about that.

STATEMENT OF DEPUTY ADMINISTRATOR

Dr. DRYDEN. Dr. Glennan has described to you the general objectives and philosophy of the research and development activities by which our long-range goals are to be reached.

These activities are very varied in nature. A part of them are carried out—perhaps 20 percent or 25 percent—in the facilities of the Government with Government people, and the other 75 percent or so are carried out in the plants and laboratories of industry and universities. These activities at some stage culminate in a launching—which is the thing most obvious to people looking at the program

from the outside—a launching in which we attempt to carry out one of the objectives related to the long-range planning.

The last launching, as you know, was on Friday, March 11, and I will talk about that a little bit later.

1959 OPERATIONS

Last year when I appeared before you we had just gotten into business as NASA. We had to talk mainly about what we were going to do and had very little to say about what had been done because of the short time the agency had been in existence.

During the course of this last year we have made an aggressive start on the space exploration program and we have obtained results which are of solid value—very important information which we will use in the later stages of the program and which people in other scientific areas will also use.

We have during this year developed a long-range program. We will review and keep the plan continually current.

First, however, I will describe what happened during calendar year 1959. As shown on this chart, there were successes which are shown in the heavy black and out to the margin. There were failures which are shown in gray and indented. This is a complete history of our major launchings.

We have determined what we think is the cause of the failure in each case and have taken the remedial steps to be sure that that same thing does not happen in later flights. You can see that our record improved slightly during the year.

We made only four attempts in the first half of the year. We made a good many more in the last half of the year. So, the tempo has been increased somewhat and the record of successes is improving slightly as we go along.

LAUNCHING OF VANGUARD II

On February 17 this satellite—VANGUARD II, the first experiment in developing a meteorological satellite—was launched. The facts about its weight and the closest approach to the earth and farthest distance from the earth are shown here. The batteries in it were active for 27 days. The satellite will stay up for more than 10 years as a silent satellite. It carried two photocells for photographing the cloud cover. In this launching the last stage did not separate cleanly. There was a disturbance which caused the satellite to wobble. The result has been that while all of the electronics equipment functioned perfectly and information was transmitted, we are still in the process of trying to analyze the rather complicated motion of this satellite to find out where it was looking when the particular readings were taken.

Mr. OSTERTAG. It is still in orbit, Doctor?

Dr. DRYDEN. Yes, sir.

Mr. YATES. Dr. Dryden, this chart indicates that the satellite was up for 27 days?

Dr. DRYDEN. The batteries were active for 27 days. It is still up but is silent.

Mr. YATES. Is that a sufficient length of time to give you the research information that you want?

Dr. DRYDEN. This gave us a crude picture of the weather, if you like, and we were able to obtain the data on the cloud cover of the earth for 27 days. We expect the later meteorological satellites to transmit data for a lot longer time. This is the reason we are interested in nuclear auxiliary power systems which will last almost an indefinite time. That is the reason we are interested in solar power which can be used when the requirements are not too great, and some of the satellites I will show you later, which use solar cells, will continue transmitting indefinitely. VANGUARD I is still broadcasting signals—the little ball with its solar batteries. It will stay up for 200 years. Whether it will keep on sending radio signals for 200 years, I do not think anyone can say.

LAUNCHING OF PIONEER IV

March 3 we had another success in PIONEER IV, a lunar probe which went out to orbit around the sun. It was with this vehicle that we were able to make measurements of the radiation fields out to a distance of 407,000 miles. That is the distance record for communications which has just been broken by PIONEER V launched last Friday, which we will talk about later. In this case I do not know whether the batteries gave out or whether it simply got so far away that the radio signals became too weak to receive.

Mr. JONAS. When you said it was a record, you mean it was a world record?

Dr. DRYDEN. A world record, yes, sir.

Mr. YATES. Farther than any which the Russians have sent up?

Dr. DRYDEN. Yes, sir.

Dr. GLENNAN. It should be pointed out that the equivalnt Russian satellite weighed 900 pounds and therefore they could have carried transmitters of higher power.

Dr. DRYDEN. This one, of course, will stay in orbit around the sun indefinitely. I do not know whether we will ever see it again because it is pretty small to pick up.

Mr. OSTERTAG. What has that accomplished?

Dr. DRYDEN. We made measurements to the distance that I have mentioned over a period of 82 hours. It was the first time that such measurements were made out at this distance although the Russians, of course, have some now also to the distance of the moon.

Mr. OSTERTAG. Off the record.

(Discussion off the record.)

FAILURE OF A VANGUARD LAUNCHING ATTEMPT

Dr. DRYDEN. We then had this period of disappointment. On April 13, in the VANGUARD launching attempt, something went wrong with the second stage separation so that it tumbled and landed in the ocean a short distance away. I will not stop to go into these separation problems, but one of the things which we have found in some of our vehicles is that a solid propellent rocket, after the main burning is over, has little slivers and bits of shavings left inside which then burn and give an extra kick. So, it sometimes goes farther than

intended and bumps the final stage knocking it off course. Now, to avoid this we trip it over out of the way with a device or gadget so that if it does have this after-burning, it will go off at an angle rather than go ahead and bump the next stage which is in flight.

Mr. JONAS. Have you developed any figures which you could put in the record to show what the VANGUARD cost?

We expect failures, understand, but a lot of people are disturbed over the cost of the program.

Dr. DRYDEN. About $110 million, I think for the entire VANGUARD program. There is a very detailed report by the staff of the House Appropriations Committee, Mr. Thomas, which has very complete details on the VANGUARD.

Mr. JONAS. Do you mean details on just this one?

Dr. DRYDEN. On the whole VANGUARD program. These VANGUARD shots constitute our winding up of the vehicles that were left from the IGY. There were three successful launchings—which is a success rate of about 30 percent—not much different from the record for any of the other vehicles. The only trouble was that the failures came at the wrong time. The failures came first. Actually, the statistics are somewhat worse but not a whole lot worse than those for many other programs.

JUNO II FAILURE

You will notice here [indicating] a Juno II failure. That is the same type of vehicle that put up the first U.S. satellite, the EXPLORER I. They fail sometimes, too. In this case there was a failure of the guidance power supply. You probably saw the picture of the failure in the paper. The vehicle started leaning over horizontally and it was destroyed by the range safety officer 5 seconds after launch. Such failures occur in all vehicles. We are gradually learning more about them and the record is improving.

Dr. GLENNAN. May I interrupt to say to Mr. Ostertag, Mr. Chairman, that I would be surprised if history does not show that the VANGUARD was one of the best investments this Nation ever made in this kind of work. The results that have been obtained from the three satellites that were successful, the training that went on—as a matter of fact, practically everything we use today has some part of the VANGUARD in it. So, while it was a costly thing——

Dr. DRYDEN. The scientific equipment in the first EXPLORER came from the VANGUARD. Otherwise, it could not have been ready.

Mr. OSTERTAG. It was a pioneering success, then, so to speak?

Dr. DRYDEN. Yes, sir.

Dr. GLENNAN. I would refer you to the last but one of the issues of the Saturday Review where there is a very fine, exciting discussion of this first little VANGUARD or "grapefruit," so-called, what has come from it and what continues to come from it.

LAUNCHING OF EXPLORER VI

Dr. DRYDEN. The other VANGUARD had a helium regulator failure. Then on August 7 came EXPLORER VI, the first of the "paddle wheel" satellites, which was the most complex launching by our country up to that time. It did have solar power and it

was launched on a highly eccentric orbit primarily for reasons of the scientific experiments. It was able to dip down into the radiation belt at 157 miles altitude and go out to 26,383 miles. In the launching there was apparently some slight damage to one or two of the paddles. It was active for 60 days, but then there was a failure and radio transmission stopped. Either the batteries ran down because they were not getting enough energy to keep them charged, or there was a failure in the transmitter itself.

Mr. OSTERTAG. May I interrupt at that point to ask you a question with reference to the fans or paddles? That is the means by which you charge your batteries?

Dr. DRYDEN. Yes, sir.

Mr. OSTERTAG. Those will continue to work, will they not, or are they intended to work longer?

Dr. DRYDEN. They are intended to continue to work. We are finding that there are some problems.

If these materials are not protected from the high intensity of ultraviolet light, they are damaged somewhat.

In VANGUARD I we were apparently very fortunate in getting the kind of glass cover for it which has protected it for a long time.

Mr. OSTERTAG. As long as those paddles work, will the batteries and the general mechanism of the satellite continue to work?

Dr. DRYDEN. There are other places where it can fail, but you are right generally. In this particular case, as I mentioned, a couple of the paddles were not fully extended and the charging current was somewhat low. I do not know whether the batteries ran down or whether there was a failure in the transmitter at the end of 60 days.

LITTLE JOE FIRINGS

Then, we had two more failures; another JUNO II—an upper stage altitude control malfunction knocked it off course. Then there was the first of our so-called LITTLE JOE firings. The LITTLE JOE firings are connected with development of the MERCURY satellite and they are not orbital firings but ballistic firings. The first one went off prematurely. The escape rocket went off on the launching stand a half-hour before the LITTLE JOE rocket was supposed to be launched. The LITTLE JOE booster rocket was not affected and stayed on the ground and was used over again. This was traced to a wiring error. The wiring in some of these things is very complicated, and in this particular case I suppose in the long run you would blame it on human error when we make a mistake in wiring.

LAUNCHING OF BIG JOE

On September 9 another of the MERCURY development tests, BIG JOE, was launched. This had the MERCURY capsule without the escape tower mounted on an ATLAS booster. Its purpose was to test, under realistic conditions of reentry, the heat shield that was to be used to protect the man in the final capsule. In this particular launch the two outside engines of the ATLAS, which are supposed to drop off at a proper point in the trajectory, failed to come off. For this reason the BIG JOE trajectory in some ways gave a more severe test than the actual reentry will; in some other aspects it did not quite

match actual reentry conditions, but it gave us a great deal of confidence. The heat shield came back in perfect condition. The temperatures inside the capsule were perfectly within the tolerance of man. About as important was the exercise given to the recovery system set up by the Navy to locate and recover the capsule after the flight. Because of the failure of the first-stage engines to separate, the capsule fell several hundred miles short of the predicted impact point; nevertheless, the Navy located it within an hour or an hour and a half and picked it up in about 6 hours. So, this was a realistic test of the recovery of the capsule and this whole exercise gave us a great deal of confidence; so much so we did not see that it was necessary to make a second test of this character.

We do have another flight of this kind coming up with the actual capsule as built by McDonnell some time rather shortly now.

LAUNCHING OF VANGUARD III

The next and final VANGUARD in the series, VANGUARD III, was a successful shot. This had a third stage rocket of somewhat improved performance so that the payload weight was now 50 pounds rather than 20 pounds as in the earlier VANGUARDS. It, again, was launched into an elliptical orbit. Its primary instrumentation was a magnetometer which measures the earth's magnetic field. In this case the batteries were active for 84 days, but because of the high apogee this object will stay up there for 30 or 40 years.

Then, next, we had scheduled a lunar shot on which we had counted rather heavily in this prestige business. On September 24 this blew up on the test stand during a static test of the engines. The payload was not in place. Therefore, the loss there was of the basic vehicle. We will come to another trial a little bit later.

LITTLE JOE FIRING

Then, as you recall, the first LITTLE JOE firing had not gone correctly before; on October 4 there was a successful firing of this so-called LITTLE JOE. The capsule, the escape tower and the escape rocket and this gadgetry [indicating] will pull the man out of a bad situation should there be trouble during the launch of the ATLAS. If the ATLAS blows up, he can push a button and the escape rocket will kick him up in the air and allow him to land by parachute. It is a special form of ejection seat, if you like. This first test was merely a test of the basic LITTLE JOE booster systems. In addition, the booster destruct system was deliberately activated in order to make sure that it would function properly in case it were needed on future flights.

LAUNCHING OF EXPLORER VII

On October 13 EXPLORER VII, which is the so-called heavy IGY satellite, was launched. It carried a large number of experiments which were a part of the IGY program. This satellite weighed 91½ pounds and had five experiments on it. It will be active for about a year and will remain in orbit about 20 years.

Mr. OSTERTAG. Have you any reports from it yet?

Dr. DRYDEN. EXPLORER VII is still operating. This is one of the experiments in which we have offered to give to other countries the transmitter code, and have asked them to record the observations and work up the results. The reason for that is this: In a few satellites we had included a tape recorder so that as the satellite took measurements going around the world which could then be read out as it passed over this country.

This one, EXPLORER VII, broadcasts continuously, and if other people do not record the data, it just is not obtained. It is actually to our benefit and that of other people to have others record its transmissions and work up the data. We have even offered this to Moscow but there has been no reply.

Mr. JONAS. What other nations have accepted?

Dr. SILVERSTEIN. We have sent the necessary information on the transmitter code to several, including England and France.

Mr. JONAS. You have not had any reports as yet?

Dr. SILVERSTEIN. No reports as yet. It was made available in the information system.

Mr. BOLAND. What information do you get from this mechanism?

Dr. DRYDEN. I cannot recall all of the experiments. There were five experiments, some connected with the measurement of the radiation field.

Dr. SILVERSTEIN. I think this has a cosmic ray count, it has an ionization gage, it has the scintillation counter, and a magnetometer.

Mr. BOLAND. Do you receive some of this information from other satellites that have already been launched?

Dr. SILVERSTEIN. Some of the information. This one was interesting because it has information that parallels that in our current PIONEER V. We are getting information from PIONEER V that parallels this information in the orbit.

Mr. OSTERTAG. They are not in orbit in the same area. That is the interesting thing.

Dr. SILVERSTEIN. We will be able to correlate this information out in space with the information we are getting closer in.

Dr. DRYDEN. The question is also asked: Why do you have to keep measuring radiation over and over again? The first experiments, from which you get an overall integrated measurement, are very exploratory. Then, you make apparatus which will pick out the radiation of one energy level or perhaps you are distinguishing between whether it is electrons or protons. This particular one, as I recall, had some apparatus from the University of Chicago which picked out the very high energy end of the spectrum—these particles that we are worried about in reference to biological effects. We do not know too much about what happens when these heavy atomic particles strike the human being.

Mr. OSTERTAG. This one has more weight than any of the previous EXPLORERS?

Dr. DRYDEN. Yes, sir.

Mr. OSTERTAG. Is it more sophisticated in its mechanism or is the sophistication progressively increasing?

Dr. DRYDEN. The orginal EXPLORER was based on the REDSTONE booster, and the latest ones are based——

Mr. OSTERTAG. You are talking about the satellite itself?

Dr. DRYDEN. The latest one is based on the JUPITER missile which can put up a larger weight than the REDSTONE. So, the first EXPLORER was much smaller than we can now put up using the JUPITER missile.

Mr. JONAS. I want you to say for the record why you put up the seventh when you already had six up? What were you expecting to prove with seven?

Mr. OSTERTAG. A different area.

Dr. DRYDEN. I did not quite make that point. For one thing, as we progress we have to use instruments which analyze in more detail what is up there. The second point is there is both a variation with place and a variation with time. Even some of the very rough measurements of the Van Allen Radiation Belt have shown tremendous variation in its thickness, depending on what is going on on the sun.

In a sense it is like observing the weather. It changes all the time. You are not measuring something once and for all and that is it. You are measuring the conditions in the region near the earth which are as variable in some ways as the weather. It is true that there are changes in our weather but there are certain features like being cold at the North Pole and warm at the Equator. So, the Van Allen Radiation Belt, we find, dips down near the poles and it is far out near the Equator. It is not symmetrical. In addition to that there are time fluctuations which we are trying to correlate with what happens on the sun. People look at the sun and see these big solar flares, and we look at our satellite records and see whether you find a trace of the effect of that solar flare on the instruments in the satellite.

Mr. OSTERTAG. You would say, then, there is no duplication involved in this?

Mr. DRYDEN. No, sir. You are measuring something different each time.

I am taking much more time on these than I had expected.

Mr. THOMAS. Take all the time you want.

FAILURE OF LITTLE JOE

Dr. DRYDEN. On November 4 there was a LITTLE JOE firing simulating about at a low altitude. In this case the separation rocket fired with a slight delay and we did not get quite as severe conditions as we wished, but otherwise everything functioned perfectly.

On November 26 we had a heartbreaking experience which some Members of Congress witnessed. I do not know whether any of you happened to be at Cape Canaveral at that time or not.

Mr. OSTERTAG. I was there.

Dr. DRYDEN. There was a failure of a fairing which caused premature separation of the payload. This was very heartbreaking because it turned out that although there had been a lot of wind tunnel measurements of the load on this fairing at a good many speeds, unfortunately, it was found out afterward that between two of the speeds at which the loads had been measured there was a peak in the loads and there was also a question about the margin of safety factor in the strength of the fairing. These two effects were enough to move over the line and to cause a failure. This will never happen again, I can assure you.

Mr. OSTERTAG. Are you fairly well satisfied that you have gotten all the bugs out of it?

Dr. DRYDEN. This will not happen again, I can assure you.

Then, on December 4 there was a successful high altitude test of the MERCURY escape system under full dynamic conditions. This one separated 100,000 feet up and coasted on up to 278,000 feet and landed 177 miles from Wallops. It carried a rhesus monkey.

Dr. GLENNAN. I believe its name was Sam.

PERCENTAGE OF SUCCESSFUL LAUNCHINGS

Mr. EVINS. In looking at your chart, is it safe to say that in your 1959 operations you had nine successful launchings and seven failures?

Dr. DRYDEN. That is right. It would be a little over 50 percent.

Mr. YATES. What is the relationship of your success to that of the Air Force and the Army?

About how many launchings did they have last year?

Mr. HORNER. Their rate is in the same order of magnitude.

Dr. DRYDEN. They may be up to 70 percent or so.

Mr. HORNER. It depends upon what you rank as a success. They have had a higher rate of success in actual launchings because they have been doing repetitiously the same type of launchings, for example, in the DISCOVERER series.

On the other hand, if you count as a success the final recovery of the capsule which is the intent of the DISCOVERER program, their average has been lower.

Mr. EVINS. If you were to repeat your LITTLE JOE firings several times, you could build up a higher percentage of successful launchings, but it is a question of whether to experiment in a new field?

Dr. DRYDEN. We are making an effort to get down as rapidly as we can to a comparatively few vehicles, but in the past year we have not had much choice.

Mr. EVINS. One other thing: With reference to the VANGUARD we say sometimes it is a success and sometimes we say VANGUARD is a failure. You have seen VANGUARDS listed without identification as three and four when on the other hand we have seen VANGUARD II listed as being successful and VANGUARD III was successful. How do you designate those?

Dr. DRYDEN. We have given these numbers only to the successful ones. There have been 3 successful VANGUARDS in 10 flights.

Mr. HORNER. It might be well to point out as a matter of record that we do not number any given launching until it has been successful.

Dr. DRYDEN. Assigning numbers before launch would give us much trouble in keeping records and people would want to know where the missing numbers were.

Mr. YATES. May I return to my Air Force question and ask you whether or not there is any relationship to their firings with the groups that you seek?

PIONEER V

Dr. DRYDEN. They are not making firings for the same purpose at all. I should mention, of course, that we have used the Air Force crews to fire ATLASES and to fire THORS. The last firing that I have mentioned is the March 11 firing of PIONEER V, a 26-inch satellite, a picture of which I have here. I have no charts but here is the vehicle. That is the THOR–ABLE IV vehicle. Here [indicating] is the satellite with those paddles folded up. This [indicating]

is the inside of the satellite showing some of the instruments. This has gone into an orbit around the Sun between the Earth's orbit and that of Venus. The other solar probes have been launched outward between the Earth and Mars but this was launched inward toward Venus. It is rather interesting because you have to shoot backward from the Earth and it speeds up again as it comes closer to the Sun. Someone has described it as two horses on a racetrack with the Earth running around the outer rail and Venus running around the inner rail and you send this object from the outer rail toward the inner rail.

PIONEER V will get 18 million miles closer to the sun than the Earth's orbit. Of course, since its cycle is 311 days instead of 365 days, it will get to greater and greater distances from the Earth. It will eventually be on the other side of the Earths' orbit from the Sun, which will put it 186 million miles away from the Earth at that time. But, in 5 years, roughly, it will be back in the general neighborhood of the Earth again. If we are lucky enough to have all the equipment work for 5 years, we ought to be able to pick it up again in 5 years.

Mr. OSTERTAG. For 311 days it will stay in that same position?

Dr. DRYDEN. No. It will be in an orbit around the Sun but it will take 311 days to go around; whereas, the Earth takes 365. So, it gradually gets farther and farther away from the Earth and finally it will be on the other side of the Sun from us, but in 5 years it will come back, within 10 or 20 million miles of the Earth.

This satellite has a number of experiments on total radiation, high energy component of the radiation, magnetic field and meteorites and these measurements, of course, will be made out in space where we have not been before. It also measures the inside temperature of the satellite. It has a gadget which sends an impulse when it is looking toward the Sun. PIONEER V is noteworthy because it has the most powerful transmitter that we have installed in any satellite—a 150-watt transmitter—and it is expected that this will send signals over distances of 50 million miles, and it will be less then 50 million miles from us for the next 4 months.

I have been interested to see that the papers have had this on the front page every day. I wonder if they are going to keep it up for 120 days.

Mr. OSTERTAG. What booster did you use for this?

Dr. DRYDEN. This was the THOR–ABLE IV. THOR is the booster and the ABLE IV is a growth of the VANGUARD second-stage vehicle. The probe actually has two transmitters. It has solar power. The power on the smaller one——

Dr. SILVERSTEIN. It is 5 watts.

Dr. DRYDEN. And we are using the 5-watt transmitter now for about 15 minutes out of the hour. The 150-watt transmitter later will give us 5 minutes out of the hour.

Dr. SILVERSTEIN. We can turn these transmitters on and off. We can send the signal to turn it on and shut it off. This is to conserve the batteries to be sure that we get enough charge in between time.

Mr. OSTERTAG. Does it store up the information?

Dr. DRYDEN. Yes, sir. It goes into action for 15 minutes every hour. About 20 or 30 days from now when the signals begin to get weak we will couple these two together so that the 5-watt transmitter

becomes an amplifier, feeding the 150-watt transmitter and that will be used 5 minutes out of the hour.

Mr. YATES. Did you use a military rocket for your booster?

Dr. DRYDEN. Everything we have used other than the VANGUARD has been a military IRBM rocket.

Mr. OSTERTAG. Suppost you use an ATLAS on this project?

Dr. DRYDEN. We are just beginning to get the ATLAS into use.

Mr. OSTERTAG. It would have a stronger thrust would it not?

Dr. DRYDEN. It would have put a heavier weight out.

MANNED SPACE FLIGHTS

Mr. EVINS. As a result of this year's experiments, are you closer to man-in-space flight or have you had to reevaluate your target dates?

Dr. DRYDEN. Dr. Van Allen made a speech the other day in which he said we could not put a satellite in the middle of the radiation belt and stay there with man in it or even with sensitive photographic equipment and similar apparatus because the radiation intensity is too great, but with a rather modest amount of shielding, he saw no problem in going through the belt and back through it again. There are some who say that as we get farther out there are fields of energy from the sun that we will have to do something about; one purpose of these experiments is to give us that type of information from a greater distance out into space.

Mr. EVINS. Do you think you are closer to it or further away? That is the question.

Dr. DRYDEN. We are closer to extending flight of man. We are going to accomplish manned flight very soon not only inside the radiation belt but out to greater distances.

We have many problems to solve before manned flight to the moon or a manned flight around the moon which we hope to do in about 1968.

USE OF MILITARY BOOSTERS

Mr. OSTERTAG. Before you leave that, this brings to mind that in certain of these projects, if not all of them, you are using military or Air Force missiles—the first stage; is that right?

Dr. DRYDEN. That is correct. We buy them from the military.

Mr. OSTERTAG. And a part of their procurement and production actually falls in place with your program in that you acquire them or purchase them from the military; is that correct?

Dr. DRYDEN. That is correct.

Mr. OSTERTAG. In the case of the ATLAS-ABLE, which as I understand it is a project to send a satellite around the moon—the one that you failed on Thanksgiving morning—you do have a surplus supply or rather an additional satellite ready to go?

Dr. DRYDEN. Well, in the event of a failure there may sometimes be one payload which is ready. We usually like to have three payloads; one to check and be sure it will stand the environmental condition, and one so if anything goes wrong——

Mr. OSTERTAG. At that time I understood you had three.

Dr. GLENNAN. We built three payloads, as Dr. Dryden says. One is tested—sometimes to destruction—although some parts of it are usable again. The second is put on the launch pad unit, and if something goes wrong and it cannot be fixed immediately, you just lift that off and use the third one, which is a spare.

Mr. OSTERTAG. You actually make another one?

Dr. GLENNAN. Yes, sir.

Mr. OSTERTAG. But you have no problem in acquiring the first stage?

Dr. GLENNAN. The ATLAS——

Mr. OSTERTAG. Or the rocket?

Dr. GLENNAN. No, sir.

Mr. OSTERTAG. The whole problem is from that point—from the first stage—to the payload itself; is that correct?

Dr. GLENNAN. That is correct.

Mr. YATES. But you have trouble obtaining launching pads, do you not?

Dr. DRYDEN. There is a problem of scheduling but we have been able to work that out. NASA was established on October 1, 1958. This PIONEER V was authorized by Dr. Glennan and myself within the first month. We are just now beginning to fire the vehicles on which we made decisions after we took over. Practically everything else that we have fired had been planned in the Department of Defense or elsewhere before NASA ever existed.

This year to a year and a half is about the leadtime it takes to do an experiment with a vehicle that already exists.

You asked about the use of military boosters. The ATLAS required about 5 years to develop. So we have the choice of using THORS or ATLASES or sitting around and waiting for 5 years while we go through a duplication development which would not make sense.

The vehicle program will be gone over in some detail later, but to give you some idea of the leadtime—when you have the pieces in existence the leadtime is about 1½ years and when you do not have them the leadtime is perhaps 4 or 5 years.

FUTURE LAUNCHING PROGRAM

Mr. JONAS. You made your second and last ABLE effort within 60 days of the first failure. You are not ready to announce when you are going to try again, are you?

Dr. DRYDEN. Dr. Silverstein will give you the details of this later.

I want to close by giving very roughly what is in the years ahead. In the sounding rocket program we continue at a level about the same as the IGY level of 100 or 110 firings. Many people ask: Why do you have to use sounding rockets at all? In the first place, we find it advisable to launch equipment of the type you see on the sounding rocket before the same equipment goes in the satellite. A sounding rocket costs $25,000 or $30,000. With it you can subject equipment to many of the same stresses it will later encounter in a satellite launch. The other point is that the satellite measurements extend from roughly a hundred miles up. A satellite at a hundred miles won't stay up very long, and you use sounding rockets to continue your measurements down at lower altitudes than the satellites give you.

Mr. OSTERTAG. Was the ATLAS–ABLE project planned before you took over?

Dr. DRYDEN. This is in the same group. Dr. Glennan and I authorized three firings—the VENUS firing originally scheduled in

June of 1959, if you will recall, and it became quite obvious that we had underestimated the time required to get these things ready. We have a year's experience now. We are able to do better in estimating when we can do something.

I previously described the 4 satellites and 1 probe which were successfully launched in 10 attempts. We obtained a lot of information as I have described. Satellite activity will continue at about the same rate. In the applications area, we have the passive communications satellite, the 100-foot sphere. I expect some of you saw one of the three ballistic firings we made to check out the payload package in the last stage of the rocket on the 16th of January, 18th of February, and 27th of February. In these firings, the balloon was launched to an altitude of 250 miles, inflated to a diameter of 100 feet. It was traveling about 9,000 miles an hour and was visible all up and down the eastern seaboard. One of them I saw from the airport at Newark; probably you have seen this one or one of the others.

The actual satellite firing will take place within the next few months, we hope. There are other firings in the communications mission covered by the estimates that are before you.

In the meteorological satellite field there will be a TIROS shot fairly soon—two of those this year. This will be followed by NIMBUS, a more complex device. I will not review Project MERCURY. The amount in the budget, we think, will bring suborbital flight of a man this year and sometime next year the orbital flight of the astronaut.

I talked before about the long leadtime question. The estimates that are before you cover spacecraft, as we call the object that goes in orbit, second and third generation experiments, and more advanced scientific satellites. One which is of interest to a great many people is an astronomical telescope, to be stabilized and pointed with a very high degree of accuracy, perhaps of the order of 1 second of arc. The advanced research work on this project is being done in our Ames Research Center. This will follow through to industrial development of the stabilization system.

The astronomers are busy with their designs and plans for what they want to measure and the kind of telescope that is to be built, et cetera.

There is money in here to prepare for advanced lunar missions. Again, this will be described in some detail.

The pace will step up to about 30 major launchings per year, roughly double the number for this year. The ones this year were mainly financed in the years before, although some 1960 funds are necessary in completing them.

The vehicles program includes the continued development of the ATLAS CENTAUR vehicle, money for the SATURN the lower stage booster and the upper stages, the F–1 million and a half pound engine, ROVER rocket, and for auxiliary power—some substitute for batteries that will last longer and give more power to run instrumentation; this will be specifically necessary when we are able to put two or three thousand pounds into orbit—and electrical propulsion, which has been mentioned.

INTERNATIONAL PROGRAM

I would like to mention very briefly the fact that we have brought other nations into a cooperative relationship with this program. The Space Act authorizes and directs us to cooperate with other nations in space activities.

What has happened, briefly, is this: There have been many discussions, some at the initiative of other countries, some in which we have taken the initiative. They follow a pattern in which we, as representatives of NASA, describe the organization in this country, the fact that there is a civilian program and a military space program, how the civilian program is set up, and the desire of the Congress and NASA to have cooperation from other countries.

The nature of the talks differs somewhat with each country. The talk that we had, say, with Argentina, which has very little capability at the moment but is interested in meteorological-sounding rockets, dealt with their interest in seeing if we might train a man or two in sounding rocket work. At the other end of the scale are our discussions with the British about a cooperative project in which we will furnish a solid propellent rocket, the SCOUT, and they will furnish the payload. We have talked with the countries about the desired pattern of cooperation. This is one program in which we are not subsidizing other nations. The British, for example, appropriate money to construct their own experiments and payloads—experiments of the type which we would do normally in our program if they did not do them—so, to a certain extent you might say that the British Government is taking a part of this load of space exploration.

Our contribution, of course, is the larger, but there is no exchange of funds. They furnish the people, pay travel expenses, furnish equipment, et cetera.

Our international activities cover the exchange of information like the IGY exchange, with which you are familiar, like exchange of people. Our tracking and telemetry activities around the world involve us in discussions with many other nations. In a number of cases we have been able to get their support to the extent where the other nation will take the entire operating cost.

Mr. OSTERTAG. Doctor, dollarwise, how much does our expenditure compare with the British, just in round figures on an annual basis?

Dr. DRYDEN. In this project?

Mr. EVINS. Not in one particular project, but overall. How much are we spending on an annual basis as compared to the British in this field?

Dr. DRYDEN. In our varied program we, of course, will be spending $900 million. Do you recall the British figure? I don't recall it offhand.

Dr. SILVERSTEIN. It is less than a million dollars.

Dr. DRYDEN. In the order of a million dollars would be my guess.

COSTS OF LAUNCHINGS

Mr. YATES. On a comparable question, Doctor, you have declared the cost of VANGUARD I was approximately $110 million. Can you give us the total cost of all the launchings that you have listed on that chart?

Dr. DRYDEN. We can supply it. I could not give it to you right offhand. This is the mission product.

Mr. YATES. Is this the total budget of NASA?

Dr. DRYDEN. No. If you took the direct cost of these activities this would account for—I don't know. Do you have a guess?

Dr. SILVERSTEIN. I would not want to guess. We can furnish it for the record.

(The information requested is as follows:)

Feb. 17, VANGUARD II	[1] $8,672,000
Mar. 3, PIONEER IV	[2] 4,501,000
Apr. 13, VANGUARD	[1] 8,672,000
June 22, VANGUARD	[1] 8,672,000
July 16, JUNO II	[2] 4,501,000
Aug. 7, EXPLORER VI	9,504,000
Aug. 14, JUNO II	3,156,000
Aug. 21, LITTLE JOE	[3] 978,000
Sept. 9, BIG JOE	6,201,000
Sept. 18, VANGUARD III	[1] 8,672,000
Sept. 24, ATLAS-ABLE	[4] 9,728,000
Oct. 4, LITTLE JOE	[3] 978,000
Oct. 13, EXPLORER VII	[2] 4,744,000
Nov. 4, LITTLE JOE	[3] 978,000
Nov. 26, ATLAS-ABLE	[4] 3,115,000
Dec. 4, LITTLE JOE	[3] 978,000

[1] The VANGUARD costs are derived by prorating the total program cost (including salaries and development but excluding construction) over 11 launch attempts.
[2] The PIONEER III, PIONEER IV, BEACON, and 2 EXPLORER VII's were developed and launched for $22,504,606. These costs are each one-fifth of the total, with the data analysis costs for EXPLORER VII added.
[3] The total estimate for 6 LITTLE JOE launches (not yet complete) is $5,868,000.
[4] The first ATLAS-ABLE included all development and payload costs; the 2d ATLAS-ABLE costs include only booster hardware and minor modifications.

Dr. DRYDEN. In order to do all these things there is much in the way of advanced research and development which has to be done, and which is not normally charged as a direct cost, so that you are likely to be a little misled by direct costs only. You would be misled if you thought we could do this job with the numbers written down as a direct cost to these flights. This is what I am trying to say.

Mr. YATES. You have indicated that the cost of VANGUARD I would be so much. I wondered whether you had record of the cost of VANGUARD II, PIONEER, and the others listed on the chart.

Dr. DRYDEN. When we stated the cost of VANGUARD, that covered the whole development program of VANGUARD, which included not only the rockets, scientific instrumentation—which was used in the EXPLORERS—tracking networks we have inherited which largely came out of that $110 million, minitrack stations, optical stations around the world, so that the $110 million is the total expenditure for 10 VANGUARDS and all payloads and tracking equipment.

Mr. EVINS. It is obvious we are gaining a great deal of information. It is valuable and worthwhile. We applaud your Agency for it, but what are we getting in return from others? We are spending vast sums of money and we are immediately making it available to others. What are we getting in return, quid pro quo? Can you put your finger on a few specifics we are gaining from others?

Dr. DRYDEN. We are getting in return from other nations the scientific ideas and talent that come from another group of people who are extremely capable in the field of science generally. This is the main return. We have an intangible return that I do not know how

to measure, in holding up the morale and interest of the Western nations in the United States. In fact, this is by sharp contrast with the present attitude of the U.S.S.R. We are willing to cooperate with them. So far the U.S.S.R. has not admitted other nations into their scientific program, other than Iron Curtain countries.

CLASSIFICATION OF INFORMATION

Mr. OSTERTAG. On that point, Doctor, all of the information and developments that take place in connection with space exploration and your project, generally, you do not reveal to the world generally everything that is evolved, do you?

Dr. DRYDEN. If there is anything which is considered to have military significance and value, this is classified.

Mr. OSTERTAG. How do you determine whether it might or might not have military significance?

Dr. DRYDEN. In the same way we do any classification job.

If the chairman would permit, I did make a progress report in considerable detail on the national program.

Mr. THOMAS. You take all the time you want.

Dr. DRYDEN. I would like to simply put a speech into the record, which was a progress report on our international activities.

COST OF LAUNCHINGS

Mr. THOMAS. I think you might clarify the point raised by Mr. Yates. It is generally thought that the direct cost on one of these big firings, a military proposition, the direct cost, cost of engines, instrumentation and everything, as was expressed to me at Canaveral when I asked for the direct cost, was $3½ to $5 million.

Dr. DRYDEN. That is bare cost of the vehicle.

Mr. THOMAS. When you put the research and development cost on it perhaps it was between $40 and $50 million that that one firing cost.

Dr. DRYDEN. There is a cost figure in between. Our bill for THOR-ABLE is about $14 million.

Dr. SILVERSTEIN. One shot?

Dr. DRYDEN. Yes.

Dr. SILVERSTEIN. It is between $10 to $14 million, depending on how you divide it up.

Dr. GLENNAN. These are subject to the vagaries of the accounting system. If you took 10 VANGUARDS and the total program costs $110 million, are you justified in saying each shot cost $11 million? The actual hardware for each of those shots might have cost a million or a million and a half dollars. As to the development cost, it is just as you treat the development cost of a motorcar. When Ford put out the Edsel, they said they had spent a quarter of a billion dollars making the first Edsel. Then they spread that cost over all the cars produced. They are selling a product. Unfortunately, we have only a few units over which to spread our development costs.

Dr. DRYDEN. For the SATURN vehicle, it might cost a half billion dollars for the first one.

Dr. GLENNAN. Yes.

Dr. SILVERSTEIN. In VANGUARD, this project which cost about $110 million, we developed in that program the upper stages used in

the rocket that was fired on the 11th, PIONEER V. The ABLE stages were a product of the VANGUARD development, second and third stage financed in the VANGUARD program. In the same way the first solar cells we financed in VANGUARD I were also operated in this program. The telemetry developments are used later. The minitrack stations we have put down in the VANGUARD program are being used now in all of our satellite programs so this initial investment and the initial investments we are making in this program are simply building the base or the groundwork for continuing the program in the future.

Mr. JONAS. We can agree we are not dealing in peanuts in the cost of this program.

PROGRESS ON INTERNATIONAL PROGRAM

Dr. DRYDEN. I simply wanted to ask permission to put in the record this speech, rather than to take the time to talk for another half hour. It amounts to a progress report on the international program. It tells you in detail what we are involved in with each nation.

Mr. THOMAS. Give us the highlights of it. We will get it from you now.

Dr. DRYDEN. I think the major program, of course, is an agreement with the British that we will devote three SCOUTS in our program to scientific payloads which have been built in England. Beyond this point the British are considering developing their own satellite vehicles, based on their current ballistic missiles. They are doing design work now. The Government has not decided whether the British are going to build their own satellites or not.

In the case of Canada we are cooperating, first, in some sounding rockets at Fort Churchill. The Canadian Telecommunications Laboratory is building a special instrument called the topside ionosphere sounder for making some measurements of the ionosphere from above. We now measure from below by sending signals up from the ground and reflecting them from the ionosphere.

The Australians have expressed interest in a payload which would measure the radio noise from the stars in the very low frequency region, a radio astronomy experiment.

There have been exploratory discussions with the French, the Swedes, Norwegians, Italians, Japanese. These are still in the early discussion stages.

Mr. EVINS. Does your report show that the telemeter systems of our country are being used on a grant basis to the other countries?

Dr. DRYDEN. I do not quite know what you mean. I do not know of any exchange of actual apparatus. In the case of the British experiments, we will provide the telemetry. It has to be consistent with our world net. They will provide only the scientific instrumentation and the satellite shell.

Discussions with other countries are still in the early stages.

We have adopted the view that we do not want to do work purely for training, purely for allowing other people to get experience; the experiments must be a part of the program that we would otherwise do for ourselves.

You will not find in this budget anything set out specifically for international activities other than, I think, an identification of the

three SCOUTS in the series that are to be used in the British experiments.

This is the only one that is solid at the present time.

From here on Mr. Horner is going to talk about resources and then General Ostrander, details of the vehicle program; Mr. Silverstein the schedules, and Mr. Abbott, advanced research.

Mr. OSTERTAG. Doctor, in connection with the British development, they have a rocket of their own; do they not, or a missile?

Dr. DRYDEN. They have a missile of their own under development.

Mr. OSTERTAG. It is not operational?

Dr. DRYDEN. It is not operational as yet.

STATEMENT OF THE ASSOCIATE ADMINISTRATOR

Mr. HORNER. It is my purpose to extend the remarks of the Administrator and Dr. Dryden in discussing with you our resources, the facilities and personnel which we are integrating into our R. & D. organization, the funds that have been made available to us in the first 2 years of the life of the organization and the request for new obligating authority which is before the committee at this time.

We think the sums we are requesting represent an optimum match of staff, facilities, program, and financial support. General Ostrander, Dr. Silverstein, and Mr. Abbott will describe in greater detail the content of the technical program and relate the various elements of the fund requirements to the program.

GROWTH OF PROGRAM

To provide background information for the budget request, I think it is interesting to note the level of funding which has been provided for in prior years. The first chart, provides a comparison of the dollar magnitude of the NASA program in fiscal years 1959, 1960, and 1961. These sums would indicate a rapidly expanding program. However, the rate of growth of the program is not solely a result of the maturation of active development projects since in each of the last 2 years substantial new responsibilities have been assigned to NASA as our national space effort has been defined and focused on the twin objectives of space exploration and the application of space vehicles. For example, only a few months ago responsibility for development of superboosters was assigned to NASA and has resulted in a major addition to our staffing and our fund requirements.

Regardless of the reasons for the growth, however, the rapid rate has extended our management capability to the limit of its capacity. The extra hours and added assignments have become a rule for our staff, both at the Washington headquarters and in the field centers.

It is only in this way that we have been able to maintain work schedules and though we do have occasional development failures, that bring severe disappointment, they also bring added determination on the part of all to bring success to the highly diversified and broadly cast program which we have initiated.

In the area of financial management, you will be interested to know that substantially all of the money appropriated for program support in fiscal year 1959 has been obligated to project activity. The program implementation performance has been equally satisfactory dur-

ing the current fiscal year, with funds being committed at the scheduled rate, and I would like to assure you that this is not just a process of committing funds for the primary purpose of maintaining a schedule of expenditures.

VARIANCE IN ESTIMATES

Mr. THOMAS. I wonder if the gentleman will yield there briefly?

In the first place, let me say that the committee is wholeheartedly in sympathy with your program, with your plowed and unplowed fields. Naturally, there has to be a lot of guesswork in your program. The nature of the proposition does not lend itself to anything approaching mathematical accuracy.

If you knew all the answers, you would not need this research and development program.

On your salaries, it is understandable that they are in the neighborhood of $170 million. You have so many bodies at so much annual pay. You can arrive at that figure. For construction, and for research and development you have roughly $750 million—$122 million for construction and about $621 million for research and development. That $750 million is composed of two or three hundred or more items of expense.

Just what yardstick do you use to arrive at those figures?

In the first place, are they based upon open, competitive bid? Obviously the answer is bound to be "No" at this particular stage because you have not submitted them to any contractors. In your judgment, I know the figures are the best figures that you are able to arrive at but certainly in arriving at them there must be a variance of anywhere from 5, 15, or 25 percent in your estimate.

Is that a fair statement?

Dr. GLENNAN. No, sir. I would like to take that on, Mr. Thomas.

Mr. THOMAS. We are going to take you all on. You had better all take a try at it.

You be first.

Dr. GLENNAN. These estimates are made by people who have been active in this business for some years and who have had similar responsibilities, have had the task of carrying out a program which has facets similar to these so that these are not guesses. These are estimates, of course, but they are sound engineering estimates. They do not have the factors which I think you must tend to include when you say 15 to 25 percent cushion in figures of this sort.

Mr. THOMAS. How do you know what X project is going to cost? You haven't submitted it to a contractor. How do you arrive at it?

Dr. GLENNAN. We arrive at it by estimating based on past experience. I know of no other way to do it.

Mr. THOMAS. You have not had any past experience.

Dr. GLENNAN. Every person I think on the staff that we have—that is an exaggeration, perhaps, but the very, very great bulk of them have had a great deal of experience in these and similar fields.

Mr. THOMAS. No question about that, but you have not had experience in building this exact same project. That is what I am talking about.

Dr. GLENNAN. No, sir. I hope we do not have to go through it twice.

Mr. THOMAS. Just how do you arrive at that? Take this. This is the Langley Research Center. You have a dynamics research

laboratory. Of course, this is just one of the small items of cost. This is only a $4 million item. Of course, it is not exactly chicken-feed, at that. How firm are these figures? Your building will cost $519,000.

Dr. DRYDEN. They are made by the people who have designed our equipment in the past. In many of the places in the book, Mr. Thomas, you will find three columns: 1959, which is numbers from actual contracts; 1960, a mixture, some of them are actual contracts, some are estimates; 1961 is an estimate.

Mr. THOMAS. Mostly your figures are for expenditure this year. They are new items.

Dr. GLENNAN. You are speaking only of construction and equipment now?

Mr. THOMAS. Yes. I assume some will go to the other.

Dr. GLENNAN. My comment went to the other.

Mr. THOMAS. These are not firm figures because you have not put them out to contract.

Dr. DRYDEN. That is correct. They are made by architects and engineers who have designed all of the equipment that you see when you go to one of our stations.

Mr. THOMAS. Doctor, you are the only agency that I know of that will admit that your figures are firm. We see a lot of construction in a lot of other scientific agencies. I believe you were the first one to admit 4 or 5 years ago that your figures were subject to variance of 10 to 15 percent in the old National Advisory Committee for Aeronautics.

Dr. DRYDEN. They are estimates, sir.

Mr. THOMAS. May I say for the record that when the committee and Dr. Dryden finally leveled on a figure, that you performed within that figure and you always did a beautiful job.

Dr. DRYDEN. We changed the plans to stay within the money you allowed. We do not build the same thing we estimate for you at 10 percent less cost.

Mr. THOMAS. Your construction was always A-No. 1, was it not?

Dr. DRYDEN. We build a useful facility but it is not exactly the one described, when funds are cut 10 percent.

Mr. THOMAS. Did it do the job you had in mind?

Dr. DRYDEN. It did a job, not quite the same job.

Mr. THOMAS. How much variance was there?

Dr. DRYDEN. I would say, of course, that no estimate can be exactly accurate but you cannot take a cut of 10 percent and do exactly the same thing.

Perhaps once in a long while when the construction market goes down, some months later we might get the original project for the reduced amount. In other cases prices go up.

Mr. THOMAS. Take in a building where you allow $30 a square foot for construction. If you build the same building, have a good roof on it, you cut it down to about $18 to $20 a square foot. It does not hurt you, does it?

Dr. DRYDEN. The usual thing is to cut off some of the length of a wing or that sort of thing. That is the way we stay within the money we have.

Mr. THOMAS. Does it serve the same purpose and do the same job?

Dr. DRYDEN. Not exactly.

We have had no great complaint about our experience with the committee over many years on construction. I think you have in most cases given us the equipment to meet our needs to keep current. It has not always been the same equipment we desired in the first place. These are the best estimates we could make of what we would need and what we think we need would cost.

Mr. THOMAS. With leadtimes of 18 to 36 months, I just do not see how you arrive at all these round figures and say that they are not subject to variance from 15 to 25 percent.

Mr. ULMER. I think it is fair to say they are subject to variance. Some bids come in higher than we estimate, some lower. Instead of the 15 to 20 percent figure, I would like to go to the variance figure permitted by the authorization bill, which recognizes that there may be a 5 percent variance, either up or down in these figures, and that variance provision is carried in the authorizing legislation. As I said, it is true these are not firm bid prices, but they are based on the experience of the people who have been building scientific facilities of this type for many years.

Mr. THOMAS. You have not plowed too many fields of this exact nature, have you?

Dr. DRYDEN. It is pretty close.

Dr. SILVERSTEIN. The particular number you picked out, $519,000 for the building at Langley——

Mr. THOMAS. That was just one of them.

Dr. SILVERSTEIN. I realize. The man responsible for this estimate is Mr. Messick, who for 30 years, and I knew him 30 years ago when he was down at Langley, has been doing this work and he is now head of the group down there. He has done nothing during that time except to build our buildings, and he has created some $150 million worth of buildings in that time period and I think his estimate is probably a continuation of his experience.

Mr. JONAS. Thirty years ago you were a barefoot boy.

Dr. SILVERSTEIN. I was at Langley and I knew him.

Mr. THOMAS. What does that add up to? He is a good man. Nobody is trying to take a shine off him. How accurate are the figures?

Dr. SILVERSTEIN. As stated, the figures are estimates and if during the time, before we acquire the money, the market goes up some, then this figure will be too low. If the market should come down some, it might be too much. That is the kind of figures they are. They are based on engineering estimates. This type of building construction, of course, is fairly firm in the market. Good engineering organizations can figure them.

There is some other construction that is not as firm when we go in for the most up-to-date equipment; we do run into problems where we have to kind of tailor the thing in terms of the market at the time. We do tailor and have had to tailor all of our equipment this way.

(Discussion off the record.)

Mr. THOMAS. You do not have any salaries mixed up in your research and development program, do you?

Mr. HORNER. Only to the extent we contract with an outside laboratory or company.

Mr. THOMAS. That applies to your JPL plant, but beyond that?

Mr. HORNER. No.

Mr. THOMAS. As a matter of fact, there is a specific limitation in the appropriation bill preventing just that.

Mr. HORNER. That is right. Almost all of our R. & D. account goes for industry and of course industry does support salaried personnel with that funding but the point I was making was that we do have good advanced planning information on those projects that are currently active. The uncertainty is generally related to dates of accomplishment rather than rates of expenditure that are already established in the industrial contracts.

Mr. THOMAS. Gentlemen, let us get some lunch and get back at 1 if we can.

AFTERNOON SESSION

Mr. THOMAS. The committee will please come to order. I believe Mr. Horner was making a statement when we adjourned. You may proceed, Mr. Horner.

GROWTH OF PROGRAM

Mr. HORNER. One other aspect of the growth of the space program which requires understanding is the increasing dependence on American industry for accomplishment of development work. In contrast to the practice of NASA's predecessor organization, the NACA, where the bulk of the research programs were carried out by use of the in-house capabilities of the research centers, there has now been added a dominating increment of hardward development effort which will for the most part be contracted with industry. The next chart illustrates this situation. The variation in the fraction of the effort which is carried out in Government laboratories during the 3 years that are shown reflects the assimilation into the Administration of new organizational elements, such as the Development Operations Division of the Army Ballistic Missile Agency. During fiscal year 1961 more than two-thirds of NASA's work will be implemented by contract. This proportion will become even greater in future years.

RESOURCES ESSENTIAL TO PROGRAM

I would like to turn now to the specific resources that are essential to our program implementation. These are the facilities and manpower which we are integrating into our organization. As I have mentioned the overall complex of our organizational structure has been created largely by the melding of existing organizational units into the Administration. The nucleus was provided by the 8,040 staff members of the laboratories and headquarters of the NACA. To this were added 400 members from the VANGUARD Team of the Naval Research Laboratory. In the first fiscal year of NASA's existence 700 new positions were provided, and an additional 950 are required in the current fiscal year to round out the staff and provide technical and scientific skills that were not present in the older laboratories but are required for this new business of space exploration. The proposed budget program reflects an additional increase to a total strength of 16,373 in the Administration.

This staffing level and the costs pertaining thereto are summarized on the next chart. The 1960 total staffing for purposes of comparison

is set at 10,086. Of the total proposed increase of 6,287—5,400 or about 90 percent results from the assimilation of the single group at Huntsville, Ala., under the leadership of Dr. von Braun. The staffs at the headquarters and at the older field centers will remain at the levels established for 1960 and the increase in new hiring of 887 employees is applied to the needs of the Goddard Space Flight Center and the Wallops Station. This growth is required to supplement and balance the skills needed for the space flight programs and to provide for their effective integration into the existing effort.

As you can see, the first 18 months of our organizational history have been devoted largely to assimilating existing groups into a coherent and effective working structure. Concurrently, we have had to develop and begin the implementation of a complex program of unusually high scientific and technical content. Furthermore, all of these activities have been carried out in the presence of, and carefully coordinated with, those of other interested Government, scientific, and industrial organizations. With these circumstances, it is understandable that increases in our headquarters staff during 1960 were inescapable. We recognize that at least part of the work burden at the headquarters is interim in nature, and we have therefore strongly resisted expanding beyond what we foresee as the long-term needs of a more stable organization and program growth. The net result, as I mentioned earlier, has been long hours and concerted effort by most of our staff. We scarcely see how we could have accomplished our objectives without the staff growth which has been realized, nor can we anticipate proper performance with less than the stated requirements in the appropriation request for your present consideration.

With the added workload of the recent assignment of responsibility for development of superboosters, a new element to the headquarters staff has been created. Recognizing the absolute essentiality of attaining the best possible launch vehicle performance in terms of timely availability of load lifting capacity, and paying respect to the resulting need for reducing the numbers of types of launch vehicles in order to improve reliability, the staff function of directing launch vehicle development and operations has been separated from the balance of the space flight programs. This has resulted in the functional staff organization at headquarters as we see on this chart.

Aside from the Office of the Administrator and the special staff offices he requires, the four functional staff elements now include the Office of Business Administration, the Office of Advanced Research Programs, the Office of Space Flight Programs, and the new Office of Launch Vehicle Programs. You will recall that a few days ago we announced our intention to add a fifth functional element to this listing—the Office of Life Sciences Programs. In this connection, a Director of the Office has been named—Dr. Clark Randt—but no further staff additions have as yet been made. It is anticipated that, although this staff element will be relatively small, it will be highly specialized in the critically important skills of the biological sciences.

The total staff strength for the administration is intended to be 16,373 people. It is our policy to delegate the responsibility for program implementation and detailed program initiation to the field centers as rapidly and as completely as practicable. Functional areas of responsibility have been assigned to each of the centers, and I be-

lieve it is worthwhile to discuss each of them briefly. You might also be interested in refreshing your memories as to the geographic location of each of these centers on this large map of the United States. The relative position of each center in our organization, with the channel of communication and responsibility to the headquarters staff, is indicated on this chart.

The Langley, Lewis, Ames and Flight Research Centers are the laboratory centers which constituted the research capability of the NACA. Organizationally and for program integration purposes, they report to the Office of Advanced Research Programs in the headquarters. Although their individual staff levels have been stabilized for the past few years and the proposed staff strengths for fiscal year 1961 exactly coincide with the fiscal year 1960 staff numbers, the program of work at each of these centers has undergone a major change in the past 1½ years. Whereas, by far the bulk of the work of 2 years ago was oriented toward the current and advanced needs of aeronautical developments, the combination of significantly reduced numbers of aircraft development projects in the United States and the needs for research in support of the space flight program have rapidly shifted the emphasis of research efforts at the centers to the astronautics end of the spectrum.

RESEARCH CENTER STAFFING

Mr. THOMAS. How did you use all that big personnel load at those installations without any reduction? I have not been able to get a satisfactory answer to that. Apparently, based upon your own justifications, it is going to be from 12 to 18 to 24 months and in some instances 36 months until you are fully implemented in the way of new buildings and modernized equipment to go into the space work. During all that period of time I see no reduction in your present personnel load.

Mr. HORNER. I think, Mr. Chairman, that this is a process of evolution. It is very difficult to say when we will be fully implemented in terms of new facilities, new equipment and new buildings to have the program completely oriented toward the space effort.

In the first place, we do have some continuing responsibilities in the aeronautical field. Approximately 25 percent of the effort at the research centers is in support of aeronautical research. This will be described later by Mr. Abbott.

In the reorientation of the balance of the people toward the astronautics end of the spectrum there has been a continuous retraining process and a continuous adaptation of facilities. I am sure that this work force will become more effective as the years go by, but it constituted the best source of talented people for training into this space program—the best source we could find anywhere in the United States.

Dr. DRYDEN. When we appeared before you in 1958, at that time we were at a level of about 25 percent in space and 75 percent aeronautics. I remember you making the comment that this shift ought to be accelerated. By the time we appeared in 1959, I think it was more like 50 percent to 60 percent in space, and it is about 75 percent now. So, this is a process which has gone on since about January 1958.

During this time, both in 1958 and 1959, you have approved facilities for the research centers which have aided in this move toward the emphasis on space. So, it has been going on about a year and a half from practically zero in 1957 to 25 percent in 1958, to about 50 percent, or a little more, in 1959 and about 75 percent now.

Mr. THOMAS. The point that I raised is that during that changeover period there has not been any reduction in personnel.

Dr. DRYDEN. No, because you have a demand which is still going on to hurry up and catch up with the Russians. We do not do that by cutting out research on space.

Mr. YATES. Did not the President say we were not engaged in any race with Russia?

Dr. DRYDEN. No; I do not think he said anything like that.

Mr. YATES. He declared in one of his press conferences we were in no race with the Russians.

Dr. DRYDEN. He said our program should not be determined by what they were doing.

Mr. THOMAS. There has not certainly been any effort or any tendency in the laboratories to save any money. Instead of that, we had a certain amount of appropriated money and you just spent it.

Dr. DRYDEN. In January 1958 the Congress began to discuss the organization of the space activity and I think it was in April that the President sent to Congress a recommendation that the new agency be created, based on NACA and he directed the old NACA to get ready to take on this space burden. You do not get ready by reducing people. It is going to take many more people than NACA had. Very early, of course, was the transfer of the VANGUARD people.

Mr. THOMAS. But you have not transferred any of those people outside of a few of your top people.

Dr. DRYDEN. We took about 300 of the best people on the research side and moved them over in undertaking these key responsibilities. Mr. Silverstein is one, and many of his staff, as well as Goddard's staff and the Langely project people, all came from the old NACA laboratories.

Mr. THOMAS. You had 400 out at the Naval Laboratory. They did not come from the old NACA installation.

Dr. DRYDEN. That is right.

Mr. THOMAS. Where are they now? Are they located at Goddard?

Dr. DRYDEN. They are a part of Goddard.

Mr. HORNER. There have been very strong pressures, Mr. Chairman, to increase the staffing at the research centers in view of the increased responsibilities. In many respects the space research responsibilities are additive to those that are still going on in aeronautical research.

Mr. THOMAS. You may proceed.

Mr. HORNER. This change has resulted in substantial problems for our research center staffs in reorganizing and retraining for the new tasks, hiring in new technical disciplines as the effort in areas of waning interest is decreased, the modification of old facilities, and the creation of new to accommodate the new research regimes. This reorientation is progressing at a very satisfactory rate.

LANGLEY RESEARCH CENTER

This photograph shows a major portion of the facilities at the Langley Research Center—facilities which have been created at a total cost of $154 million. At this center a staff of 3,220 will conduct the research program in fiscal year 1961 at a total program cost of approximately $50 million. This includes the salaries for the total staff, the research and development expenses, and the cost of a major facility addition which will be able to simulate the gas temperatures and velocities which will be encountered by a space vehicle returning to the earth's atmosphere, a facility which is essential to the solution of key problems in our ongoing program. Major areas of work at the Langley Research Center include research in structures and materials, the aerodynamics of reentry vehicles, continuing work in aircraft aerodynamics and fundamental research in plasma physics. This center is located near Hampton, Va., and is the oldest and the largest of the research establishments.

LEWIS RESEARCH CENTER

The Lewis Research Center, located at Cleveland, Ohio, represents a facility investment of $148 million and employs a staff of 2,736 people. An aerial view of the facilities of the center are shown in this photograph. Its primary research mission is investigation related to propulsion. Research programs are now active on chemical rockets with emphasis on high energy propellants, on nuclear rockets, and on electrical propulsion devices. Electrical power generation in support of this latter area of propulsion research also requires major attention from the center.

AMES RESEARCH CENTER

At the Ames Research Center, in the Santa Clara Valley of California, on the Moffett Naval Air Station, a staff of 1,440 conducts a comprehensive research program in facilities with an original construction value of $107 million. An aerial view of these facilities is shown in this photograph. The principal areas of work are space environmental physics, including simulation techniques, gas dynamics research at extreme speeds, and automatic stabilization, guidance and control of space vehicles. There are also under experimental evaluation at this center several full-scale models of vertical takeoff and landing craft.

FLIGHT RESEARCH CENTER

The Flight Research Center at Edwards, Calif., is a relatively small but unique and highly specialized facility, shown in this photograph. On the edge of Rogers Dry Lake, it takes advantage of the 75-square-mile flat surface as an ideal testing ground for research aircraft. Four hundred and sixteen staff members are currently concentrating most of their efforts on the flight evaluation of the X–15. A limited number of flights have already been conducted by the contractor's flight crew. It is anticipated that center personnel will shortly begin the flight research program wherein the pilot will be propelled sub-

stantially above the earth's atmosphere and experience the characteristics of space flight for a duration of a few minutes. The coming year should be one of high interest in this project if the program goes as expected.

SPACE FLIGHT CENTERS

In the space flight side of the program there are three major research and development centers at work and three locations in which we have varying levels of investment for purposes of launching space vehicles. As I have already indicated, we have divided the work into two categories—launch vehicle development and operations on the one hand, and spacecraft development and operations on the other.

Two centers are primarily engaged in spacecraft development and, again, a functional division in the work has provided to the Goddard Space Flight Center the primary responsibility for those projects concerned with earth orbiting craft both in their development and operation as well as supporting research and test as necessary for the mission. It is at this center that the VANGUARD team served as a nucleus for a staff which is projected to grow until it numbers 2,000 with the proposed fiscal year 1961 budget authorization. The staff is currently housed in several different locations in the Washington area and at the Langley Research Center. However, the badly needed space research facilities for this center are under construction at Greenbelt, Md., and the first of these will become available for beneficial occupancy by the middle of this summer. The satellite and sounding rocket program, the manned space flight program, and the application of space vehicles, including passive communications and meteorology, are the major program elements of this center.

Mr. EVINS. Do you have any pictures of Goddard?

Mr. HORNER. No, sir; not with us at this time. It is currently under construction.

The responsibility for the other major area of spacecraft development is assigned to the Jet Propulsion Laboratory at Pasadena, Calif. It is the exploration of deep space, including the lunar and interplanetary flights. This Laboratory is employed in our program through the medium of a contract with the California Institute of Technology. The staff at the present time totals approximately 2,700 people, including several hundred currently engaged in the systems engineering of an Army weapon, the SERGEANT ballistic missile. As the activity on this weapons system is phased out, we expect some decrease in the total staff size, but our present plans indicate that a stable requirement will persist for about 2,400 people. An aerial view of the facilities which the Laboratory occupies in the foothills of the Sierra Madre is shown.

The launch vehicle development and operation task is assigned to the NASA Huntsville facility. I know you are all aware that the decision to transfer this facility to NASA was taken recently, and implicit approval of the plan to carry out this decision is about to be granted by the Congress.

Mr. THOMAS. What is the dollar cost this year as compared to last year?

Mr. HORNER. Of the Huntsville facilities?

Mr. THOMAS. Of the Jet Propulsion Laboratory.

Mr. HORNER. You are referring to the total program cost, Mr. Chairman?

Mr. THOMAS. No, I am referring to your salaries and expenses. You receive an appropriation for your construction there but what about your salaries and expenses? Where is that table? I cannot put my hands on it. You have a very good table for all of the rest of them but I cannot find this one.

Mr. HORNER. The reason that one is different, Mr. Chairman, is because we pay that by contract out of the research and development account and it is not paid for out of the salaries and expenses account. We are actually supporting that Laboratory with the research and development program. The salaries as such are not broken out in that same item.

Mr. OSTERTAG. Is it identifiable?

Mr. THOMAS. Do you have a breakdown of what you spent on that Laboratory with the exception of your construction cost which is appropriated directly?

Mr. HORNER. We do not have it in this program but we will be glad to provide it to you. It is not in this statement.

Mr. THOMAS. That does not do us very much good now, does it? Can you give us a figure on it?

Mr. HORNER. Yes, sir. The average employment at the Laboratory during the next fiscal year will be very close to 2,400 people. This is at an average salary, as I recall, of around $8,000.

Mr. THOMAS. What were your cost figures in 1959 before you took it over from the Air Force, and what are they in 1960 and 1961?

We would like to have a comparison of it. I cannot find it in your justifications.

Do you have that information available?

Dr. SILVERSTEIN. I can give you some round numbers, but I think the personnel in 1959 at about the time we took it over was around 2,400 people. There are currently about 2,700 people aboard, and I think for the budget we have here in fiscal year 1961 the estimate for salaries and related costs is around $20 million. About $16 million is included for supplies, materials, and equipment and for other items in support of the Laboratory. In addition the Laboratory will monitor around $27 million in program contract funds during 1961 which will bring their total funding up to a figure of around $63 million.

Mr. THOMAS. Give us a total on it. Certainly, that should not be left out of your justifications in the first place. However, give us a table showing 1959, 1960, and 1961 for your salaries and other objects.

Your construction money is set out separately so we can get a view of that, but I want to compare your operations with what the Army did. I think we have a picture of that under the Huntsville operations.

(The information requested is on page 359.)

Mr. THOMAS. You may proceed.

Mr. HORNER. It provides, as I have already noted, for a transfer of 5,500 people under the leadership of Dr. von Braun. The development facilities which will also be transferred had an original investment cost of approximately $100 million. The major project activity of the group at the present time is, and for some time will be, the development of the SATURN booster and the integration of the upper stages. There are also numerous other activities at this center, including work on several Army missile systems, which will be carried on in accordance with the agreements we have made with the Department of Defense.

ATLANTIC MISSILE RANGE

As I have stated, the responsibility for launch vehicle operation as well as development comes under the Von Braun group. For this purpose a missile firing laboratory is maintained at the Atlantic Missile Range at Cape Canaveral, Fla., which will supervise all NASA vehicle launchings from that site and will actually carry out the launching of vehicles developed at Huntsville.

PACIFIC MISSILE RANGE

In the time period pertinent to this appropriation request, we will also have some space flight operations from the Pacific Missile Range. We plan to launch from this location all spacecraft which require polar orbits. Although the launch operations will be carried out largely by contract, a small group of NASA technical and administrative liaison people will be located at the site.

WALLOPS ISLAND STATION

At Wallops Island, off the Virginia coast, we have a small launching service organization which conducts the numerous launchings of our sounding rocket program and the solid propellant orbital vehicle which we will bring into service during the current calendar year. A staff of 300 people operates a facility valued at $18 million which is shown in this aerial photograph. The work is largely in response to the needs of the sounding rocket and satellite program.

WESTERN OPERATIONS OFFICE

To round out the organizational picture, is the western operations office. This office is established in Santa Monica, Calif., with a staff of about 40 people. Its function is to perform liaison with the many development contractors engaged in our program and to carry out contract administration as required. The existence of this office greatly reduces the requirement for travel to this area by personnel of the headquarters and various other centers.

CONSTRUCTION

To supplement this summary view of our current facilities, I would like to comment briefly on the request before you for new construction. The next chart shows a summary of our program requirements for

the next fiscal year. The total request is for $122,787,000. These funds will be used to create new facilities for the accommodation of the changing research and development requirements. It is the minimum essential investment to provide the pressing needs for our essential inhouse project activity as well as laboratory and test facilities for the supporting research so essential as the foundation for our entire program. Although the National Aeronautics and Space Administration inherited a substantial complex of excellent facilities at the existing NACA laboratories, the space exploration program demands a continuing investment to modernize and convert existing facilities as the requirements evolve and construct entirely new facilities where new technical disciplines in research or testing must be covered.

PROVISION FOR FACILITIES

Of the current request, about 15 percent is for provision of facilities at our research centers to make possible the continuing supporting research program. The balance of the facilities requested are directly in support of space experimentation, most of it at the three space flight centers and the Cape Canaveral launch site.

INVENTORY LEVEL

Mr. THOMAS. What is your inventory at your three stations now? You might include the JPL Center, because in the final analysis you will pay for that too, but confine your remarks to Langley, Ames, and Lewis?

What is your inventory there of expendable supplies for research? Do you have that figure available?

Mr. HORNER. No, sir.

Mr. ULMER. Around $3 to $4 million, mostly for stockroom supplies.

Mr. THOMAS. Do you intend to build that inventory up in 1961?

Mr. HORNER. There will be an increase because of the Huntsville facility. You do not include that particular facility in your question.

Mr. THOMAS. No; I confined it to those three. You say it is $3 million or $4 million?

Mr. ULMER. I think it is closer to $3 million, sir.

Mr. THOMAS. What do you intend that figure to be in 1961?

Mr. ULMER. About $3 million plus the inventory we will acquire from the Huntsville activity.

Mr. THOMAS. What is your inventory at Huntsville and what do you intend to build it up to in 1961? What is your take-over inventory—not buildings and warehouses—but your expendable supplies?

Dr. DRYDEN. There is $18 million to be divided between NASA and the Army.

Mr. THOMAS. At Huntsville?

Dr. DRYDEN. Yes.

Mr. HORNER. The Huntsville activity is in one aspect an industrial-type activity which leads to a different inventory.

Mr. THOMAS. On what percentage will you divide with the Army?

Mr. SIEPERT. Mr. Chairman, no percentage has been agreed upon. The only thing that the Army and NASA could reach agreement on is to go over with task force and give categories of supplies on an arrangement in which the Army will retain all supplies which are

peculiar to their missile systems and we will share common use items that both NASA and the Army can use together.

The figure of $18 million was an initial figure they had which included a large amount of obsolete materials. They are trying to get a better and more realistic inventory figure than the one that we gave.

Mr. OSTERTAG. You are speaking now about equipment and inventory generally; is that true?

Mr. SIEPERT. I am speaking of the amount which the Army record shows as in the custody of the T.M. & E. organization—that is the Technical Materials and Equipment organization—which is their main stock inventory organization. It does not include the cost of issued equipment which is in use at the laboratories.

Mr. OSTERTAG. But, these inventories do not embrace physical plant facilities of any kind?

Mr. SIEPERT. No, sir. Those were in the $100 million figure that Mr. Horner mentioned.

NASA PLANT INVESTMENT

Mr. OSTERTAG. Do we have any estimate as to the overall fiscal value of NASA properties?

Mr. ULMER. The total is about $450 million to $500 million.

Mr. EVINS. That would be about $500 million?

Mr. OSTERTAG. About $500 million?

Mr. ULMER. Yes, sir.

Mr. OSTERTAG. That is exclusive of any program which is in the making?

Mr. ULMER. Correct, sir.

Mr. THOMAS. You may proceed, Mr. Horner.

COORDINATION OF SPACE PROGRAM WITH DOD

Mr. HORNER. Mr. Chairman, I would like to turn now for just a brief period to another subject which has been of extreme importance to us and has occupied a great deal of our attention. This is the matter of our program coordination with the space efforts of the Department of Defense. I want to emphasize, first, that we have an excellent relationship with the military departments and the Office of the Secretary of Defense. Program correlation and project coordination are thorough and compatible with our needs, as I believe they are with the needs of the Department of Defense. I have had a chart prepared which I think illustrates the coordination as it currently exists. A few facts stand out. Space exploration is the responsibility of NASA. Military applications are the responsibility of the Department of Defense. Civil applications are the responsibility of NASA. There are some applications which are of interest to both military and civil needs. The underlying research and technical development is largely useful in both programs and common use can be made of launch vehicles. Therefore, in the areas of certain applications—launch vehicle development, and background research and development—careful coordination is required to assure that full value accrues in joint utilization of either agency's products. The chart shows examples of these coordinating devices. Again, I repeat, they

are working well. When undesirable duplication is identified, it is eliminated and there is tremendous payoff in the programs of each for the benefit of the other.

Mr. THOMAS. Be specific. What have you eliminated from your program because it was being duplicated in the armed services and vice versa? What have the armed services eliminated by virtue of the fact that you were engaged in it?

Mr. HORNER. Perhaps more important, Mr. Chairman, are the things that we have not initiated because of the presence of the other program, and this is true on both sides. However, there have been some cases where projects have actually been started and then terminated on our side.

Mr. THOMAS. You gave up the VEGA project of about $42 million, for one.

Mr. HORNER. Yes, sir; I was just going to mention it.

Mr. THOMAS. What becomes of that $42 million which you had allocated to that project?

Mr. HORNER. The $42 million, sir, is not directly applicable to VEGA as a vehicle. This was a lunar exploration program and the VEGA vehicle was being used in this program. A part of the money was, of course, nonrecoverable from the VEGA development. Most of the balance of the money is continued in application toward the development of spacecraft which will be used now on the ATLAS AGENA out of the Defense Department development program. There are other examples.

We are doing, for example, meteorological development effort and the Department of Defense is doing navigation. We are doing passive communications and the Department of Defense is doing active communications. We both have a continuing and important interest in all of these projects. We will safeguard our interest from the civil——

Mr. THOMAS. What do you mean by "passive communications"? Do you mean strengthening your radio and radars?

Mr. HORNER. No, sir. This is the use of a space orbital vehicle in a long-range communications mode by using a reflector in orbit rather than using electrically active gear in orbit.

Mr. THOMAS. You have some money under research and development for strengthening and coding your signals.

What is the Air Force and Army doing in that field?

Mr. HORNER. In that particular account that you are speaking of, Mr. Chairman, are radio devices which we use to transmit recorded data from space vehicles. We have a little different requirement than the Department of Defense in that respect because all of their vehicles are on near-earth orbits.

As Dr. Dryden discussed in some detail this morning, PIONEER V has now passed beyond the distance where any such radio signal has been received before. We need further development of such radio devices in order that we may communicate with space vehicles in what we call deep space.

Mr. THOMAS. The Army does not communicate with this ballistic missile; does it?

Mr. HORNER. Of course, the ballistic missile program is not the only space program in the Department of Defense. There are other

space programs in the Department of Defense where there is actual earth-to-satellite communication in the sense of transmittal of data.

Mr. THOMAS. That is getting into the field of NASA; is it not?

Mr. HORNER. No, sir. For example, the reconnaissance effort in the Department of Defense has a very real requirement for communication of data from the satellite to the earth. That is certainly a military application and of direct use to the Department itself.

TRANSFER OF FUNDS

Mr. OSTERTAG. I wonder with regard to this whole problem that you are discussing in response to the chairman if there is any transfer authority of funds as between NASA and the Department of Defense?

Mr. HORNER. We do use the——

Mr. OSTERTAG. Based on projects?

Mr. HORNER. We do use the project management and the project implementation capability of organizations back and forth. For example, we are responsible for carrying out the development of CENTAUR as being a vehicle of use to our program.

Mr. OSTERTAG. Are you using your money?

Mr. HORNER. We will use our money but we are using the Department of Defense contract and administrative organization to carry out the program for us. So, our money is going on a project which actually in the terms of the individual running the program is a Department of Defense individual.

Mr. OSTERTAG. But, there is no actual transferability of funds; is there?

Mr. HORNER. Oh, yes. We reimburse the Department of Defense for a great deal of hardware and all of our boosters, for example.

Mr. OSTERTAG. That is under a contractual arrangement? But, assuming, in line with the chairman's question, with regard to suddenly finding that something is a military rather than an NASA project, and you have money for that particular project are you permitted to transfer your funds?

Mr. HORNER. The best example of that, of course, Mr. Ostertag, is the Project SATURN. The $140 million was originally planned in the Department of Defense. When it was determined that they did not have an immediate requirement for SATURN, the project was transferred and that authority for budgeting was transferred to NASA.

Mr. OSTERTAG. But, that was a special arrangement, was it not?

Mr. HORNER. In that sense they are all special arrangements. There have been several such arrangements.

Dr. GLENNAN. We do have authority to transfer funds.

Mr. THOMAS. I am sure Mr. Ostertag's question was directed to just what amount of money do you transfer to the Army and Air Force in 1961 and what transfers, if any, do they make to you?

Mr. HORNER. I do not think we have had that kind of analysis of our program yet, Mr. Thomas, and it would require some study to identify all of the sums that we will spend under Department of Defense contracting.

Mr. THOMAS. You are spending a whale of a lot of money in here for your tracking system.

Does the Air Force and Army use your tracking system?

Dr. DRYDEN. The data is interchanged between the two. They have some stations and we have some stations.

Mr. THOMAS. Is there any transfer of funds?

Dr. DRYDEN. Not on tracking; no, sir. In the case of the recovery operations for Project MERCURY—operations by the Navy—we have to pay the additional cost of running their ships if they have to divert ships from their usual activities. We have to pay the extra costs.

Mr. THOMAS. That is usually recovered is it not?

Dr. DRYDEN. Then, we are using military contract administration and audit personnel who are already located at the plants of certain industrial contractors. We are using their services.

Now, whether we reimburse them or not depends on whether they have to put on more people to do their job, or whether it can be added as a workload to the people already there.

Mr. THOMAS. That is true only at one or two installations; is it not?

Dr. DRYDEN. No, sir. Take, for instance the MERCURY contract with McDonnell. That is a plant under the Navy's jurisdiction. We use local Navy personnel to do the day-to-day contract administration.

Mr. THOMAS. But, you do not have too many instances of that. What else do you have? You have your McDonnell contract.

Dr. DRYDEN. The Douglas Co., Convair, Aerojet——

Mr. HORNER. Almost all of our industrial contracting which is the large part of our research and development account is placed in plants which are under the cognizance of Department of Defense contract administration.

Dr. DRYDEN. Rather than duplicating another set of administrators or auditors, we use the people already there. Our act says we can use such services with or without reimbursement.

Mr. THOMAS. Does that mean you are getting away from the Department of Defense buying a good part of your hardware then?

Dr. DRYDEN. We pay for most of it. We have some contracts in which we are simply added on to the Defense contract, and others which are independent. The McDonnell contract was made independent of the Department of Defense, but we use their people for the day-to-day audit.

Mr. THOMAS. Take the JPL, for instance, in California. Do they go out into the procurement field or to the California plant manufacturers? Do you use the Air Force, the Navy, and the Army procurement people at those plants to satisfy the needs of your propulsion laboratory?

Dr. DRYDEN. I do not know whether I can answer that offhand.

Mr. SIEPERT. To the extent that JPL would use those plants, this arrangement would be worked out. But, so far as I know, JPL has not actually placed any major contracts with them.

Dr. GLENNAN. I think, Mr. Thomas, that the MERCURY project would include elements of all this.

Mr. THOMAS. You canceled your VEGA contract. That was going to be handled by your JPL.

Dr. GLENNAN. That is right. In that sense the work was being done at Convair, paid for by NASA, but some of the contract management at plant level was being done by Air Force people. They have the bulk of the work carried on in that plant and there was no need of our putting contract-management people into Convair. To the extent that we increased the costs of the Air Force in providing us that service—that is the incremental cost—we would refund or pay for that incremental cost.

SOURCE-SELECTION BOARDS

Mr. THOMAS. I notice you have set up some contract committees in your own organization.

How many general contractors do you have?

Mr. HORNER. Are you referring to the source-selection boards, Mr. Chairman?

Mr. THOMAS. Yes.

Mr. HORNER. This is quite a different thing. This is the process of determining through an evaluation of competitive proposals which is the best and thereby selecting the particular industry.

Mr. THOMAS. Break it down. What articles does that apply to? Does it apply purely to construction?

Mr. HORNER. No; it applies to all R. & D.

Mr. THOMAS. Fabrication?

Mr. HORNER. It applies to all of our research and development procurement where the contract exceeds $1 million.

Mr. THOMAS. How does that fit in with where you have the Air Force or Navy handling it?

Mr. HORNER. We are using their services to administer contracts after they have been let. The source-determination committees are the process of letting the contracts and determining which industry is going to receive a contract. After the contract is placed in industry, say, at Convair, which is an Air Force plant, then the Air Force inspectors in that plant will assure us that we get a proper quality control. They will assure us that we get proper contract performance. In other words, it is a part of the process of assuring that the Government gets its dollar's worth for each dollar. We use the Air Force, the Army, and the Navy contract administration in that sense.

Mr. THOMAS. They are the inspectors, then?

Mr. HORNER. Yes, sir.

Mr. THOMAS. And have nothing to do with your contract?

Dr. GLENNAN. The negotiation is carried out by our people.

Mr. OSTERTAG. It ties in closely with your own procurement; does it not?

Mr. HORNER. In many places it does.

Mr. THOMAS. They do their own procurement and the Army and Navy are their inspectors.

Mr. HORNER. They have a responsibility to us to see that the contract specifications are met.

Mr. YATES. What is the function of the source committees?

Mr. HORNER. To select the contractor. If we have a development project that we want to place with industry, there might be as many as 20 or 30 different companies which would like to bid on that particular piece of business. The process of selecting which of those

companies is best qualified and will best produce the end result is a very difficult one. In order to meet that problem we usually have, in contracts that promise to be over $1 million, a source-selection committee which very thoroughly evaluates the proposals from all of these different companies.

Mr. BOLAND. Who comprise these selection committees?

Mr. HORNER. They are comprised primarily of NASA employees. In some cases where specific talents are needed, we might ask the Department of Defense to furnish members on these committees.

Mr. THOMAS. Who are your big contractors for construction?

In your supplemental you asked for some construction money and research money. About one-third of your money for construction involved overruns by your contractors. So, you started off well with them, did you not?

CONTRACT WITH WESTERN ELECTRIC CO.

Mr. HORNER. I think, perhaps, the largest contractor at the moment in construction is the Western Electric contract, which was the overrun item to which you referred. That is a rather unusual construction contract in that it is located all over the world and it is very heavily dominated by the equipment requirements.

Mr. THOMAS. I though those people were in the business of manufacturing elctrical equipment. I did not know they were contractors.

Mr. HORNER. The Western Electric Co. was chosen by a source selection board in competition with a number of other companies, each of which submitted proposals, and after a very careful evaluation, it was decided that Western Electric was best suited to do the job.

Dr. DRYDEN. They have a lot of subcontractors, including construction subcontractors.

Mr. HORNER. The actual construction is a relatively small part of this particular contract.

Mr. THOMAS. Well, they have been able to miss their guess pretty well.

Are you still satisfied that you got the best one available when they are giving you an overrun of 20 percent and 30 per cent on all the work you have given them?

What kind of contract did you give them? Was it a cost-plus, fixed-fee contract where the bigger the overrun the more the fee?

Mr. HORNER. No, sir. It is a fixed-fee contract. Exactly what the fee is I do not know, but we can provide it.

Dr. DRYDEN. I think, perhaps, it might be well to put in the record the particular complications in this contract. As mentioned, they are located in a great many different countries and all require intergovernmental agreements. There is a time schedule on this, and if the network is to be in operation by the time we get a man in orbit, it was actually not possible for teams of contractors to go into all of these countries in advance of bidding. In fact, the final sites could not be selected until there was negotiation with the foreign governments.

Mr. YATES. Do you do any competitive bidding on contracts of this kind?

Dr. DRYDEN. It is a competitive proposal or a competitive negotiation.

Mr. YATES. What does this mean in contrast to competitive bidding?

Mr. HORNER. It means several different companies had an opportunity to submit proposals in answer to a work statement that was provided by the NASA.

The problem of this particular contract was, in this particular stage of development, we did not yet have access to most of the sites involved. It was very difficult to make an estimate as to what the costs wer going to be, and the development was in such a stage that we had to have some changes in the scope of the contract. This reflects also in an overrun.

Mr. THOMAS. You are generally criticized in your contracting activities by the old hard-nosed contractors who have forgotten more than you or the rest of us will ever know in that business. It is very difficult for them to be exactly fair and honest with you. If they give you a reasonable cost estimate and it looks a little bit high, you will give it to somebody who perhaps does not know the complete facts as well in that particular line, and they will come in with a lower figure, but when the bill is ready to be paid, it will come back in the form of an overrun which is just what you are doing now.

Dr. GLENNAN. I was simply going to say to the chairman that strangely enough the particular contract over which I got into a wrangle with the legislative committee was one in which I think the bid accepted was ninth from the lowest. It was not the lowest bid.

There are just dozens of factors that are taken into account as one attempts to determine which organization gives the best promise of fulfilling the specifications which you up to that time have been able to give them.

Mr. YATES. I do not see anything of a competitive nature in your competitive proposals. It is the usual negotiation that goes on.

Dr. GLENNAN. It is competitive before you get to the point of negotiation.

Mr. YATES. You put out a certain specification?

Dr. GLENNAN. Yes, sir.

Mr. YATES. And, you submit it to a number of companies?

Dr. GLENNAN. Yes, sir.

Mr. YATES. And, the companies come in and tell you "This is what it will cost" and "This is what we will perform the services for"?

Dr. GLENNAN. No; they tell us a great many things. They say, "We are going to put this crew of men on it," and they give us the information on each man, including his education and experience, and that gives us some idea of the manner in which they expect to go about doing the job. They give us an idea of what they think the schedule ought to be. They give us an idea of what they think the cost ought to be. We take all of those elements and fit them into the mosaic and attempt to come up with an evaluation. How do they handle their labor, what kind of management have they shown, and what has their performance been in the past? Can they keep their schedules? Are they a company which has come in consistently with a very low price initially, and then do we find ourselves paying four times that price? In other words, have they attempted to buy their way into the business? All of these elements are put into a mosaic.

BASIS FOR COMPETITIVE BIDS

Mr. YATES. Are you saying there is no basis for competitive bidding because of the nature of the contracts?

Mr. ULMER. The key difference is the detail we are able to provide in our specifications. If we build a standard building at one of our centers, we lay out everything we want, we know exactly what we are going to buy, we can put the job out on competitive bid, and perhaps 20 companies will submit bids. Then we will take the lowest bid.

In the type of contract Dr. Glennan is talking about, which involves the development of equipment that we are unable to specify in detail, we cannot get a competitive bid type of contract. We have to go to the type of procedure that Dr. Glennan mentioned where we investigate the capability of the company to work under a performance type of specification.

Mr. YATES. The answer to my question is yes; that the nature of these contracts is such that you could not submit them for competitive bidding?

Mr. HORNER. That is right.

Dr. DRYDEN. The key to it is the technical planning and understanding shown by the subcontractors. For example, there is Project Mercury. We say "We must have communication with a man 10 minutes out of every 15 minutes." As a part of his proposal, the contractor tells what radio equipment he plans to meet this technical need; we have a technical team which would make some judgment as to whether in fact each of the equipments proposed will perform as indicated.

Mr. YATES. Your contract compels the prospective contractor to come up with the idea? You are looking for ideas in this program?

Dr. DRYDEN. Yes, sir; he has an overall performance specification and he has the planning as to how to meet this specification.

Mr. OSTERTAG. In other words, there are certain unknowns which you cannot specify?

Dr. DRYDEN. That is right. There is usually a technical team and a business administrative team. The technical team decides before any proposals are in what factors they are going to consider and what they think are the important elements in this and what are the relative ratings of these items. The administrative team does the same. Sometimes there are as many as 30 or 40 people involved in this. They do a rating job on a scale of 100 percent.

Mr. YATES. Why do you not split the contract into a development contract and the actual construction contract itself?

Dr. DRYDEN. The idea is, we hope, to fly a man in orbit as early as possible in 1961, and we cannot do it unless all these ground facilities are furnished by that time.

RUSH PROGRAM VERSUS CRASH PROGRAM

Mr. YATES. Are you saying you are engaged in a crash program?

Dr. DRYDEN. It is a highly urgent, highest national priority program, yes, but not a crash program.

Mr. YATES. Off the record.

(Discussion off the record.)

Mr. YATES. I do not quite understand the difference you speak about between a highly urgent program and a crash program.

Dr. DRYDEN. In a crash program you can afford to do things two or three times to be sure that one of them works. We are trying to do it one way as safe as we can and as urgently as possible to meet a time scale.

Dr. GLENNAN. A crash program almost by definition means that you are wasting one-half the money you put out.

Mr. YATES. And that is not true here?

Dr. GLENNAN. No, sir. Take, for instance, the first missile program——

Mr. YATES. If you split the entire contract into a development contract and a construction contract, you might get the entire contract cheaper, might you not?

Dr. GLENNAN. We are going only one way on a capsule. We are not building three different kinds of capsules hoping that one of them will turn out to be better than the others. We have decided on the basis of good, sound engineering and judgment that this is the kind of capsule we want. It is the only one we are building at present. There have been many engineering changes, of course. That it why that contract has gone up somewhat in price, but these are changes which we required.

Mr. OSTERTAG. Mr. Horner, going back to this question of contracts, I assume that many of your contracts involve equipment and involve items for which the military has contracts. In connection with that do you contract with the military for such equipment and they make it a part of their contract or do they add your contract to theirs and you get the same price?

There is an area there of operation, but I do not know to what extent. Could you define that for us?

Mr. HORNER. In almost all cases we transfer the funds to the military and they amplify their contract to the extent necessary to produce the items for us on the schedule that we ask. There are some case in which there are minor incompatible schedulings and then we sit down together and adjust schedules so that we have a reasonable production schedule at the industrial plant involved. In almost all these they do the contracting where it is a military item.

Mr. OSTERTAG. In those cases the military enters into contract negotiations and establishes a price and you accept it on that basis; is that right?

Mr. HORNER. We pay usually at the going military price.

Dr. DRYDEN. For standard hardware, that is.

Mr. HORNER. I would like now to conclude my remarks by a brief reference to my last chart, which will serve as an introduction to the remaining witnesses. This chart shows our fiscal year 1961 requirements of $621,453,000 for research and development. General Ostrander will outline for you programs related to vehicle system development and space propulsion technology. Dr. Silverstein's remarks will cover space science and exploration, satellite applications, manned space flight, and tracking and data acquisition. Mr. Abbott will discuss the many related efforts at our research centers. Following them there will be amplifying reports by Dr. Pickering, Di-

rector of Jet Propulsion Laboratory, Dr. von Braun, Director of the Huntsville facility, and Mr. Harry Goett, Director of the Goddard Space Flight Center.

Mr. THOMAS. Who is next? Is Dr. Silverstein next?

Mr. HORNER. General Ostrander.

STATEMENT OF DIRECTOR, OFFICE OF LAUNCH VEHICLE PROGRAMS

General OSTRANDER. Mr. Chairman, as Mr. Horner told you, I would like to discuss our launch vehicle program, for which I am responsible and which is the area of our operations, which Dr. Glennan mentioned this morning where we most need to catch up with the Russians.

This program includes not only the vehicles themselves but also a program of advanced technology which helps us to support——

Mr. THOMAS. Let us define your activities. We have our fingers crossed on you to start with.

Are you going to tell Dr. von Braun how to run his business? Are you a scientist? Let us get your background and experience in the record.

General OSTRANDER. All right, sir; let me give you my background and I will let you judge for yourself.

Mr. THOMAS. That is very good.

General OSTRANDER. I graduated from the Military Academy in 1937 and I spent most of the war years as an ordnance officer on duty with the Army Air Force.

After the war I transferred to Air Force. I have spent the time since 1947 in the Air Force R. & D. business. I started out at Wright-Patterson Air Force Base in the old Armament Laboratory, where I first got connected with the rocket business and the guidance and control business. I then moved out to command Holloman Air Force Base, which is the Air Force installation at White Sands Proving Ground.

I moved from there to headquarters of the Air Research and Development Command where, among other things, I had staff supervision of the Force missile development program. I left there in 1958, went to NATO where I was charged with getting some guided-missile production set up in the NATO countries. Following that I was returned for a short time to the Advanced Research Projects Agency and as of last December was transferred to Dr. Glennan's organization.

Mr. THOMAS. Your work, then, is that of a businessman? You do not claim to be a scientist, do you?

General OSTRANDER. I am not a scientist; no, sir.

Mr. THOMAS. Are you a technical man?

General OSTRANDER. I would say a technical man only by background and experience.

Mr. THOMAS. Do you have any engineering degrees?

General OSTRANDER. Only the degree from the Military Academy; no graduate work.

Mr. THOMAS. You are doing a businessman's job?

General OSTRANDER. Essentially; yes, sir.

Mr. THOMAS. What business experience have you had outside of your military service?

General OSTRANDER. None whatsoever.

Mr. THOMAS. And you are responsible for spending $215 million?

General OSTRANDER. Yes, sir.

Mr. THOMAS. Go ahead.

General OSTRANDER. This program, as I say, includes both the vehicles themselves and the advance technology work which helps us support development of these vehicles and of future vehicles which are beyond what we can describe in definite form at this time. I would like to make, Mr. Chairman, just a couple of general observations before I get into the detailed description of the program.

These, I think, are pertinent to the way that we conduct our business and determine to a large degree the level of funds that we are going to need. First of all, as you well know, a rocket launch vehicle is an exceedingly complex vehicle. It has literally hundreds of components that have to function together in order to assure success, and it demands a degree of engineering refinement which you simply do not find in ordinary engineering practices.

After we have launched one of these vehicles there is neither the time nor the opportunity to make the minor adjustments that are usually possible on ground-based systems, yet the cost of failure in terms of time, of money, and of prestige is so great that we have to achieve the highest possible reliability.

NATIONAL BOOSTER VEHICLE PROGRAM

To achieve this level of reliability, and yet to try to keep the total cost of our program at something that is in earthly rather than astronomical figures, we have developed, with the cooperation of the Department of Defense, the so-called national booster vehicle program. This, I believe, has been previously presented to you. This program, as Dr. Dryden mentioned this morning, is deliberately designed to include the least number of vehicles which will do all of our presently programed jobs in space. Each one of these vehicles may not be necessarily optimum for each of the missions that it performs but we feel that the added reliability we will get by firing these vehicles over and over again, and the development costs that we will save, will more than offset the fact that they may not be precisely perfect for every job that we want to do.

I would like to, now, with your permission, review briefly each one of the vehicles in our program, after which I will touch on our advanced technology program.

I think that most of these vehicles were presented to you last year. I would like to simply refresh your memory and bring you up to date on their development status.

This first chart, the chart on your left, shows all of the vehicles currently in our development program. Some of these vehicles are interim only and will be phased out as we get better vehicles developed. The earliest available ones, the ones shown in red, are those which were mentioned this morning which were, generally speaking, put together out of components of either our military missile programs or the VANGUARD IGY program.

As times goes on, they will be phased out of the program and the remaining vehicles, the ones shown in blue, will continue on and will constitute the national booster vehicle program that I mentioned.

SCOUT VEHICLE

Starting, then, first with the vehicle next to the end, the SCOUT shown on this chart is a four-stage solid-propellant vehicle. I think its chief advantage over the rest of the vehicles in our system is its low cost. This vehicle should cost, complete, possibly as low as $500,000. The SCOUT development was initiated in 1958 and our first launching of the SCOUT is scheduled for 1960. Each one of the stages of this vehicle has been fired, the guidance system has been assembled, and the assembly of the entire system will begin very shortly.

The vehicle, as you notice, will give us something in the order of 200 pounds in a 300-nautical-mile orbit. We can also use it as a vertical probe.

We intend to use this as sort of the workhorse vehicle of our fleet. We will use it for testing of all sorts of components in near space and we can also use it in the upper atmosphere for the evaluation of such things as reentry bodies. The Air Force, incidentally, will also use various configurations of this vehicle in some of their test programs.

Mr. YATES. May I interrupt and ask a question please? Are any of these vehicles usable for ICBM military purposes?

General OSTRANDER. You will notice the first stage of many of them actually are ICBM's. They actually use the ATLAS ICBM and, in some cases, the THOR IRBM as the first stage. Generally speaking, for our purposes we have to put another stage on top to do the job that we need.

Mr. OSTERTAG. Other than the THOR and ATLAS, they are all your development rather than the military?

Dr. DRYDEN. No, actually these rockets have mostly a military history. The AGENA B is an early version of the DISCOVERER, one of the early test vehicles in the DISCOVERER program utilized this AGENA. The DISCOVERER has gone beyond this quite a ways.

Mr. OSTERTAG. How about the JUPITER?

Dr. DRYDEN. That is in JUNO II. JUPITERS will be exhausted in another five shots, as I recall.

Mr. OSTERTAG. How about the MINUTEMAN? Is that involved in your picture?

Dr. DRYDEN. Not yet.

General OSTRANDER. There is a possibility it might prove later on we can use some of the MINUTEMAN's stages as successors to the SCOUT stages.

Mr. THOMAS. Somebody ought to explain for the record just what is in one of these tubes. It is not one unit of power. There may be 6 or 8 or 10 in it. Somebody ought to explain that in understandable language. Can you do that, General?

General OSTRANDER. I am sorry.

ATLAS VEHICLE

Mr. THOMAS. What about your powerplant in your ATLAS machine? Explain it.

General OSTRANDER. In the case of the ATLAS, this consists of three liquid propellant engines with a total thrust of 365,000 pounds.

Mr. THOMAS. Three engines and you cannot fix it up where you can put a couple of boosters on top of that?

General OSTRANDER. Yes, sir, you can.

Mr. OSTERTAG. Is there a difference between ATLAS and ATLAS-ABLE?

General OSTRANDER. In the case of ATLAS they have three engines, two of which drop off after it is in flight, leaving a sustaining engine. On top of the ATLAS we put a stage or stages such as the AGENA-B to increase the velocity of the payload after we get into space.

Dr. DRYDEN. We are using ATLAS as it is in Project MERCURY. It was used for putting a military communications satellite in orbit.

Dr. GLENNAN. I have a model that I would like to bring up tomorrow that really shows you how we use the ATLAS with upper stages in its various configurations.

Mr. THOMAS. One unit will carry to a certain height and then you will pick up another unit and then you will use part of your whole configuration and then the other part will go on with separate units?

General OSTRANDER. That is right.

Dr. SILVERSTEIN. Let me give an illustration.

Mr. THOMAS. It is a complicated mechanism.

THOR-ABLE VEHICLE

Dr. SILVERSTEIN. I will give you an illustration of the flight we made on the 11th. This was what we call a THOR-ABLE vehicle, three stages. The first stage was the THOR IRBM, the intermediate-range ballistic missile, and this imparted to the whole system a velocity of around 15,000 feet a second. At that point the THOR burned out, no more fuel, and it separated and the rest was going at 15,000 feet a second. After separation, after a slight pause, we turned the second stage on, which had the same second stage we used in the VANGUARD.

This has an engine at about 7,500 pounds thrust, and it was carrying the rest of the package. It burned for 60 seconds, at which time the whole package then was going 25,000 feet a second and then it burned out. It burned fuel and oxygen up and so we dropped it off. It was dead, essentially. We separated the top stage, a solid rocket, that has about 3,500 pounds of thrust. This started to burn a few seconds after separation and it put 11,000 feet per second——

Mr. THOMAS. At what altitude were you then?

Dr. SILVERSTEIN. About 250,000 feet.

Mr. THOMAS. You were out of the Earth's atmosphere?

Dr. SILVERSTEIN. Yes. About that time, when we separated the third stage, we shed the cover off of the payload. We covered up when it was going through the atmosphere to keep it from overheating. Then when we dropped this cover, we had the solid rocket, the top stage with 3,500 pounds of thrust and the payload left. This started to burn. It burned for 35 seconds and brought the final velocity then of that package up to some 36,000 feet a second.

Mr. OSTERTAG. What causes that cover to come off?

Dr. SILVERSTEIN. It is exploded off.

Mr. OSTERTAG. Automatic?

Dr. SILVERSTEIN. As soon as you separate after a timing interval, it explodes.

Mr. THOMAS. How high do you get before you get out of the field of gravity?

Dr. SILVERSTEIN. Actually, you enter into the field of gravity of the Sun instead of that of the Earth. Gradually the Earth's field drops out and the Sun picks up. You cannot pick a particular point. I would say it is past the Moon where the Sun begins to pull it in.

Mr. THOMAS. That is a little ahead of Baltimore, then, is it not?

Dr. SILVERSTEIN. Yes. Finally, we have this payload going at 36,000 feet a second which is about the velocity to cause it to move into the influence of the Sun's gravitational field. All of these vehicles move about the same way, the multistage vehicles. Most of these are three-stage vehicles, with the exception of the AGENA stages which currently are two-stage.

Mr. THOMAS. How high up do you have to go before the power and speed at which you reach that point is sustained, with a slight diminution in the electromagnetic field?

Dr. SILVERSTEIN. For example, if we are putting a body into orbit around the Earth, a satellite, what we do is to give it enough velocity so that the centrifugal force on this body is just equal to the Earth's gravitational pull pulling it back in and then it simply stays up there. Now, there is a small——

Mr. THOMAS. At what speed?

Dr. SILVERSTEIN. At 25,000 feet per second, say, 18,000 miles an hour it will reach that condition.

Mr. THOMAS. It will remain in that same speed, then?

Dr. SILVERSTEIN. At the same speed it will keep circling the Earth. If you want to go outside of the Earth's field, then you have to give it a higher velocity of around 25,000 miles per hour to get it to go into the field of the Sun, the gravitational field of the Sun.

Mr. THOMAS. We have four or five boosters. In which one of the classifications do the Russians have the largest thrust? They do not use a single booster to go the whole distance, do they? They will use two or three boosters, too, will they not?

Dr. SILVERSTEIN. I do not know their exact booster configuration but we expect they would have to. I know of no booster you could get satellite velocities with in one stage. I do not know any way of doing it.

Mr. OSTERTAG. They must have more than one stage?

Dr. SILVERSTEIN. There is evidence they do.

Mr. THOMAS. They apparently have one booster that is three or four times as powerful as our biggest booster. As far as having innumerable boosters, do we have any information as to whether or not we are on a parity with them, or we could excel them in quantity? Could we not?

General OSTRANDER. There has been a good deal of indication that many of their shots have been done with this one type booster. What they have beyond this, I don't know.

Mr. THOMAS. But not to great heights?

General OSTRANDER. By that I meant one type of first stage.

Mr. OSTERTAG. Is that power all in the first stage?

General OSTRANDER. No, sir.

Mr. YATES. Do they excel us in development of powerful rocket fuel?

General OSTRANDER. I do not think so—only in pure size.

Dr. GLENNAN. You rate the launch vehicle on the thrust of the first stage. When we talk about the ATLAS–ABLE, we are talking about a first stage of about 360,000 or 365,000 pounds of thrust. The best estimates of the intelligence community is that the Russian first stage thrust is in the 600,000- to 800,000-pound range. In other words, double the thrust that we have at the present.

Mr. OSTERTAG. Is the SATURN expected to equal their capabilities?

General OSTRANDER. Their capability as to first stage thrust would lie somewhere, presumably, in here [pointing to chart]. In other words, we are using basically ICBM first stage boosters for all of the vehicles up until here; theirs presumably lie somewhere in the 600,000- to 800,000-pound thrust class. The SATURN will have a first stage of 1,500,000 pounds thrust.

Mr. THOMAS. Excusing the first stage, which is quite a little gap, no doubt, but on the other stages, do we have any information as to how we compare with Russia?

General OSTRANDER. I have no information.

Mr. THOMAS. What about you, Dr. Silverstein?

Dr. SILVERSTEIN. Nothing that I would think would be too authentic.

Mr. THOMAS. We certainly do have, with the exception of the first big powerful No. 1, what we might say is three or four other types of boosters that we consider pretty good, do we not?

Dr. SILVERSTEIN. Yes, sir.

General OSTRANDER. Upper stages.

GUIDANCE SYSTEMS

Mr. RHODES. I wanted to ask about guidance systems. Apparently the Russians have a fairly advanced guidance system in either their third stage or their last stage. I am thinking specifically of that moonshot. As I read the papers, they picked the worst possible time of the month to make the shot and they hit a bull's-eye, which indicated that they had a pretty advanced guidance system in that last stage.

Mr. THOMAS. The proof is there, is it not?

Mr. RHODES. Either that or they are lucky.

I do not think they were lucky.

Mr. THOMAS. Dr. Dryden has a little German scientist at Huntsville. I asked him specifically how our guidance system compared with the Russians. I did not expect any other answer than the one we got, and he said it was just as good and maybe better.

As far as I am concerned, I am going to believe him.

Dr. DRYDEN. They are too heavy to put on the THOR-based vehicles. We cannot use them until we get more thrust.

Mr. OSTERTAG. In other words, you are ahead on guidance, waiting for development of the booster?

Dr. DRYDEN. Yes.

Mr. YATES. Do you know that as a fact?

Dr. DRYDEN. We saw some of their shots in the Pacific. We know roughly what they did. We know what we do with our own guidance systems. It is certainly comparable.

Dr. SILVERSTEIN. We should qualify this by saying this is for the booster stages. There remains a lot to be done for guidance of the terminal stages, and the midcourse guidance, when we go out for the more distant missions.

In other words, the Russians did not use any actual terminal guidance in their shot to hit the moon. They did it on the basis of early stage guidance and, as we go into these more complicated missions, we are actually going to have to guide this vehicle after it is out in space.

Mr. THOMAS. They did an arithmetical calculation based on speed and distance and time?

Dr. SILVERSTEIN. Exactly.

Dr. DRYDEN. They had their guidance in the third stage and got a very accurate direction and speed at the end of the third stage.

Mr. JONAS. I think I saw in the paper this morning that somebody said that PIONEER was a little off course and wobbling a bit, is that right?

Dr. GLENNAN. Dr. Silverstein probably has the figures in mind. There was a very slight—perhaps 120 miles per hour—difference in the nominal velocity we were looking for; and there was a directional error of a very small fraction of a degree, a few tenths of a degree. This was known as soon as it was launched, but as our people would put it, it was well within the tolerance of the system.

Dr. SILVERSTEIN. The velocity that we imparted this rocket was 36,869 feet per second. I think we were off in that number by 150 feet a second. This gives you a measure of the accuracy. This is in addition to the fact that the last rocket is a solid rocket, where the ony way you have control of the velocity is simply by burning it and seeing what you get.

In other words, there is no control over the burning time. You turn it on and it burns until it completes burning.

The error of probability is what we calculated. In the later vehicles, as we move along, the upper stages will actually be controllable to give you a very definite velocity, to about a foot a second.

Dr. GLENNAN. Was there some guidance that was not used?

Dr. SILVERSTEIN. The guidance was in the second stage and it was not necessary to use it.

Dr. DRYDEN. The statement referred to was by Professor Lovell, who was doing the tracking. I suppose what he is talking about is a slight difference from a nominal trajectory.

BOOSTER THRUST

Mr. OSTERTAG. Dr. Glennan, how do we compare with Russia in all factors? We recognize that they have a thrust greater than ours; but, overall, how do we stand?

Dr. GLENNAN. Every morning at 8, I stand before the mirror and say, "We are behind the Russians in total thrust available to us, the level of thrust in our first stage boosters. In all other areas it is my considered opinion that we are not behind the Russians, that we are the equal or the better of the Russians."

I arrive at this conclusion from discussions with capable scientists and from the fact that we have published much more information from

the probes that we have sent out in little bits of packages than they have from their tremendously large gadgets.

Mr. YATES. May I ask you then how do you account for Von Braun's statement where he says we are 2 or 3 years behind the Russians?

Dr. GLENNAN. Dr. von Braun works in the rocket field. He is talking about the thrust of the rocket, and nothing else.

He may have guidance in mind, as well, because he has not been able to carry the guidance that he would like to carry, which he thinks he has on his shelves. He is not certain that this is quite as good as he might want it to be, because he has not had the opportunity to test it in flight.

Mr. YATES. If, when Dr. von Braun comes in here, and I ask him what he means by his statement, he is going to tell me we are 3 years behind the Russians in thrust and nothing more.

Dr. GLENNAN. You ask him and see what he will answer.

Mr. YATES. You are saying this is what Dr. von Braun will tell me?

Dr. GLENNAN. I think so. If he doesn't, I will be surprised.

Mr. RHODES. I want to nail one thing down. You say you have a guidance system which is as good or better than the Russians, which could be put into a second or third stage if you had the initial booster to get the thing up in the air?

Mr. YATES. That is all it is lacking, the initial booster.

Mr. RHODES. The VEGA is a vehicle which we talked about in the hearings last year and which is not now to be built, as I understand.

General OSTRANDER. That is correct.

Mr. RHODES. I asked several questions about the reason for the VEGA in the first instance, as did the chairman, and we were told that one reason that we wanted the VEGA, and one thing which we had to develop was the third stage.

Dr. Silverstein said on page 137 of last year's hearings, talking about the VEGA, the first stages, et cetera:

> When you put something on top of this, another engine has to be developed and a guidance system has to be created for it, as well, because we have to have a guidance system for the accuracy we need. Therefore, it takes a third stage engine which needs to be developed using storable propellants. This is a new development. The engine does not exist and the designs for this third stage have to be worked out.

You spent some $42 million on this VEGA vehicle, did you not?

Dr. GLENNAN. $18.3 million.

Mr. THOMAS. They had $42.8 million set aside.

Mr. RHODES. Did you get into this particular problem?

Dr. GLENNAN. Yes.

Mr. RHODES. Is the third stage developed now?

Dr. GLENNAN. The third stage is continuing in development.

General OSTRANDER. I will cover this.

Dr. GLENNAN. Before you go on, may I make a statement?

Mr. OSTERTAG. He did not finish his answer.

Dr. GLENNAN. I finished my answer, but I wanted to be responsive to your question, Mr. Ostertag.

Mr. OSTERTAG. I thought you were.

Dr. GLENNAN. I was not being facetious because this is a serious business with us. The business of trying to have people understand where we stand in the various elements of this program is tremen-

dously important to me. If I seem a little emphatic about it, I think you will understand.

Mr. OSTERTAG. I think we should be grateful for your emphasis, but what I was trying to bring into focus was the fact that you have had certain successes and you have had certain developments take place and you have a pretty good measurement of what they have done. I believe it is generally conceded that insofar as power or thrust, Russia has achieved that beyond your capability to date.

Dr. GLENNAN. At the present time.

Mr. OSTERTAG. In the overall picture, taking all things into account, our successes and our developments in many respects exceed theirs and/or equal it, and in only one field or one area of this thing are they recognized as being ahead, is that right?

Dr. GLENNAN. That is my statement, sir.

(Discussion off the record.)

Mr. THOMAS. Please proceed.

General OSTRANDER. I guess we could sum this up by saying Dr. Glennan has the cat on my back to produce the thrust he wants.

DELTA VEHICLE

Next, I would like to turn, Mr. Chairman, to the DELTA, which is shown on the fourth from the left and as a matter of fact, is a further development of the THOR–ABLE rocket which was used in last week's flight. We have made or are making a number of reliability and performance improvements over the THOR–ABLE. We have simplified the second and third stages and we have adapted a very highly accurate guidance system which was taken over from the TITAN ICBM program.

The progress on this development has been extremely good. The project was initiated early in 1959 and the first launching of this vehicle is expected probably next month. All three stages of the first vehicle have been delivered, the first flight vehicle, have been delivered to the Atlantic Missile Range and the hardware for the remaining 11 vehicles of a 12-vehicle program are on order and on schedule.

THOR AGENA B VEHICLE

Turning next to the next vehicle shown on our chart, the THOR AGENA B, this vehicle comprises a THOR IRBM as the first stage and the second stage is the same as the second stage vehicle used by the Air Force in their DISCOVERER satellite program.

This second stage vehicle was initiated by the Air Force for the Advanced Research Projects Agency early in 1959. They, as you heard this morning, have had a remarkably high reliability in their DISCOVERER program as far as putting payloads in orbit is concerned, and because of this high reliability NASA decided to use the THOR AGENA B vehicle as a replacement for the THOR-ABLE, for the THOR-DELTA, eventually, and for the JUNO II vehicle.

Our first NASA vehicle is scheduled for launch, as you see, in late 1961. We will use this primarily for scientific and for meteorological satellite missions.

Mr. RHODES. The second stage is solid propellant?

General OSTRANDER. The second stage is liquid and the third is solid.

Mr. RHODES. I do not see any third stage.

General OSTRANDER. No, I'm sorry. I was thinking about the DELTA. Yes, this is liquid.

Mr. RHODES. What kind of liquid?

General OSTRANDER. IRFNA, red fuming nitric acid, and UDMH, unsymmetrical dimethyl hydrazine. The next vehicle is the ATLAS AGENA B which is very similar to the THOR AGENA B, but obviously uses the ATLAS as the first stage booster and the same AGENA B vehicle as the second stage.

By using the ATLAS as the first stage, it will give us, as you notice, something in the order of 5,000 to 55,000 pounds in a 300 nautical mile orbit. We also have the advantage here that this vehicle, like the THOR AGENA B, will have experienced a number of firings in Air Force programs prior to our use in early 1961 for NASA purposes.

We propose to use this primarily for lunar exploration missions.

Incidentally, this is one instance, apropos of some of the questions asked previously, where we do buy both the first-stage vehicle and the basic AGENA vehicle from the Air Force on their contract. There are certain modifications to the second stage which are necessary for our purposes. These are carried in our budget, not in the vehicle development budget, but in the mission line item.

Mr. OSTERTAG. There is a difference between the picture there and the one on that chart. The top is not the payload?

Dr. DRYDEN. No, sir. This particular chart was used at one time for an unclassified briefing and since the AGENA configuration was classified we blacked it out.

Mr. JONAS. When along that list do you say you will have reached the point you are seeking with respect to thrust?

Mr. OSTERTAG. The timetable on the SATURN? Is that it?

Mr. JONAS. Why can't you skip some of those stages?

General OSTRANDER. Skip some of these?

Mr. JONAS. Yes, and start working on SATURN.

General OSTRANDER. Simply because these will come in earlier than the SATURN is available. There are many things we can do with a smaller payload capacity.

Mr. JONAS. You could not speed up SATURN by concentrating on it?

General OSTRANDER. No, sir. We have speeded up SATURN as much as we can right now.

Dr. DRYDEN. The problem is the one I mentioned. Of course, we already have the DELTA. That was a decision made early in 1959. Those vehicles are just beginning to be delivered. They are the things we will be firing over the next year. The alternative is to sit by and do nothing until SATURN comes along.

Mr. JONAS. The work on these intermediate stages is not slowing up the work on SATURN?

Dr. DRYDEN. No. They enable us to do something now.

Mr. OSTERTAG. Their objectives are somewhat different?

Dr. DRYDEN. They carry smaller payloads.

Mr. OSTERTAG. What they seek to achieve is different?

General OSTRANDER. I would like to emphasize we are always going to need a sort of a fleet of trucks. In other words, it would not pay to use the SATURN for some experiment where we only needed to carry, say, 2,000 or 3,000 pounds.

Therefore, what we are trying to do is develop as a comparison, let us say, a half-ton truck, 2-ton truck, 2½-ton truck, and 5-ton truck.

Dr. GLENNAN. I would point out, I think, in this same area, the VEGA was canceled so we would not duplicate another vehicle of essentially the same general capabilities and weightlifting and mission capability.

Dr. DRYDEN. I think it should be brought out in that connection that this was made possible because it developed that the performance of the AGENA was markedly increased. You will notice the "B" on the AGENA. The AGENA A was a vehicle of considerably less capacity. It became necessary in the DISCOVERER program to uprate the AGENA A engine to give it a greater capacity. That immediately made it able to do essentially the same job as VEGA. We then saw that we could save money in the long run by canceling VEGA at that stage. When VEGA was started, however, there was no vehicle in the military program which had this capability that we are seeking. It came about because in the DISCOVERER program it was discovered AGENA A was marginal for what they wanted to do.

Mr. THOMAS. What about the SATURN? Will that be liquid?

General OSTRANDER. The first stage will use liquid oxygen and hydrocarbons or plain old kerosene. The upper stages of the SATURN will use liquid hydrogen and oxygen as propellants. The NOVA is not a vehicle itself. It is purely a design concept based upon an engine which we now have under development which is a liquid propellent engine.

Mr. OSTERTAG. Is the SATURN all liquid, then?

General OSTRANDER. Yes, sir.

Mr. THOMAS. What are we doing in the field of solid propellants?

General OSTRANDER. I will cover this in a moment, sir.

Mr. OSTERTAG. You are coming to the SATURN now?

CENTAUR VEHICLE

General OSTRANDER. I have one other, the CENTAUR, which I wanted to cover.

The CENTAUR again uses the ATLAS as the first-stage booster, and it will use an advanced second stage which will use hydrogen and oxygen as propellants. This same technique or the same propellants will be used in the upper stages of SATURN.

The CENTAUR program includes both the development of the hydrogen-oxygen engine itself and the development of the actual stage employing these engines. The design of the engine is complete and we have had a full duration operation at the rated thrust, and the engineering design of the stage is nearing completion now. This project was initiated by ARPA in 1958 and was transferred to NASA in July of 1959. We are planning to use the CENTAUR primarily in lunar and planetary missions.

Incidentally, here again the CENTAUR project includes the cost of procurement through the Air Force of six ATLAS boosters.

Mr. OSTERTAG. How come you do not call that ATLAS-CENTAUR, or something?

General OSTRANDER. This vehicle engine and stage terminology really has not been standardized yet. I feel the same way. As a

matter of fact, I have designated one of my people to try to straighten this out so it is more understandable.

Turning now to the SATURN, which I think you are all familiar with——

Mr. RHODES. What is the first stage of the CENTAUR in the way of boost?

General OSTRANDER. The same as the ATLAS, 365,000 pounds.

SATURN VEHICLE

The SATURN project was started again under the sponsorship of the Advanced Research Projects Agency in 1959 and was transferred last November to NASA and it, of course, is our country's most ambitious active space vehicle project. It consists of a series of multistage launching vehicles with increasing payload capability. The first version of it will have, as you see here, three stages, later versions will have four and possibly five stages, using these three and adding others. The first stage which is under development by Dr. von Braun's organization down at Huntsville has a total thrust of 1,500,000 pounds, which is achieved by clustering eight modified ICBM engines.

Mr. OSTERTAG. ICBM's?

General OSTRANDER. ICBM. A static firing of this first stage is scheduled for next month down at Huntsville. We have chosen the configuration of the second stage and we now have industry bidding on its design and construction, and the third stage on this configuration is exactly the same, or nearly exactly the same as the CENTAUR upper stage that I mentioned.

The first development launch of this vehicle, which will consist merely of the first stage with dummy upper stages, will take place from the Atlantic Missile Range in 1961. We will then go into a total of 10 vehicle development flights, and the first so-called operational vehicle which is the 11th vehicle is scheduled for launch in the first quarter of 1964.

We will use SATURN primarily for advanced manned missions.

ADVANCED PROPULSION TECHNOLOGY

Turning now from the vehicles themselves to the advanced propulsion technology program, which I mentioned, this program of course provides us the background and the advanced research and development work for these and for future vehicles. It includes research and development on new chemical engines, and support of the joint NASA-AEC nuclear rocket program. It contains work in the areas of electrical space propulsion and also work on auxiliary power units for space missions.

Taking first the chemical program, we have work going on both on solid and liquid rocket technology. Solid rockets have several inherent advantages over liquid-propellent systems. They are simple in construction, and they are usually quite reliable.

They can be transported in a loaded condition. They are relatively easy to launch and their ground support equipment is relatively simple.

Admittedly, the chemical energy you can pack into a premixed solid rocket composition is somewhat lower than the energy that you normally can get out of liquid-propellent combinations, but in spite

of this, there are a lot of missions where this simplicity of handling of transporting and of operating outweighs their lesser performance. Consequently, we do have a continuing solid rocket program. Our program is limited primarily to those aspects of solid propellants which are pointed specifically toward missions in space. We have deliberately kept our program somewhat small because of the quite massive effort that is going on in the Department of Defense under the impetus of such programs as MINUTEMAN, POLARIS, PERSHING, et cetera.

Mr. THOMAS. What is the fuel used in the solid-propellent rockets?

General OSTRANDER. There are a number of different fuels. It is basically a rubber, or a plastic binder containing the fuel and oxidizer which combine in burning through the nozzle.

Mr. THOMAS. What is the fuel, though?

Mr. HORNER. A hydrocarbon binder in every case, containing the oxidizer in the matrix.

Mr. THOMAS. What is the hydrocarbon a byproduct of?

Mr. HORNER. Rubber.

Mr. THOMAS. Do these use anything else besides rubber?

Mr. HORNER. Most of the new propellants have some content of the light metals to improve the specific impulse.

Mr. THOMAS. What is the oxidizer that you mix with it?

Mr. HORNER. Either a nitrate or phosphate.

General OSTRANDER. Very frequently they will mix finely divided aluminum which increases the thrust.

Mr. THOMAS. Do you use any metal besides aluminum?

General OSTRANDER. Other metals have been tried. Aluminum is the one that is used most to date.

Mr. THOMAS. What is the chemical formula, Dr. Silverstein?

Dr. SILVERSTEIN. Of the rubber base?

Mr. THOMAS. Yes.

Dr. SILVERSTEIN. It would take a page to write it out. It is one of these very complex rubber molecules.

Mr. THOMAS. Will it take that much time? Do you have a blackboard here?

Dr. SILVERSTEIN. I cannot write out the long rubber molecule that is used.

Mr. HORNER. Every development agency has their own composition in this. They all vary a little bit as to the stability of the molecule. The chemical formulas are very complex and vary from one contractor to the other.

Dr. DRYDEN. It is something like polyurethane.

Mr. HORNER. That is a development of the Aerojet General Corp.

Mr. THOMAS. The basis of it is hydrocarbon?

Dr. SILVERSTEIN. Yes, big molecules. They are all polymers.

General OSTRANDER. These comparisons are always dangerous but as a rough idea, by going from what you might call conventional propellants to our hydrogen-oxygen combination that we use in CENTAUR, we can roughly double the thrust that we obtain and going from that to a nuclear rocket, you can again roughly double the thrust.

Mr. EVINS. You had about 16 launchings in 1959. How many do you schedule or have planned for 1960?

Dr. DRYDEN. About 30.

Dr. SILVERSTEIN. It is in the order of 30. I will have a chart shortly that will show these numbers.

Mr. OSTERTAG. We had a list of them.

I would like to ask Dr. Silverstein or General Ostrander about the SATURN. Is it fair to say that the SATURN is a radical departure from all other rockets that have been used or developed up to this point?

General OSTRANDER. No, sir. I would say not. It is simply an extrapolation in size.

Dr. DRYDEN. It is an eight-cylinder engine where the ATLAS is three.

Mr. OSTERTAG. That is primarily what I meant as constituting a radical departure. You have eight boosters within one and they have to be coordinated to operate together. In other words, where you might have one chance of lack of explosion you have to have eight of them working constantly together.

Let me ask you this: Are you putting all your eggs in the SATURN basket or is there any other basic approach to getting that much power and thrust that is so essential for your ultimate weapon or satellite?

General OSTRANDER. I will cover that later and I think our alternative is in this F–1 engine, which we now have under development.

Mr. OSTERTAG. That is even beyond the SATURN?

General OSTRANDER. Yes, sir; it is.

Mr. OSTERTAG. You are concentrating on the SATURN and that is only one type of vehicle. There are no experimentations involved in any other form of doing this?

Dr. DRYDEN. That is a half billion dollar project. You cannot afford very many of them.

Mr. OSTERTAG. That is a good point.

Dr. SILVERSTEIN. May I say here the SATURN is an unusual vehicle in the sense that it will have quite high performance for its basic thrust, of a million and a half pounds. We are using this new fuel from the upper stages, hydrogen and oxygen. The CENTAUR for the first time will use these fuels in an actual vehicle. It is very important to the SATURN program because it will give us the experience to enable us to assure ourselves that the SATURN will work when we call upon it to work. There is a growth of experience from the CENTAUR into the SATURN. SATURN is unusual since no one has yet flown any vehicle with the hydrogen-oxygen fuels. These fuels do give you capability which is roughly twice that of the conventional fuels in a lunar mission.

Mr. OSTERTAG. Do you know whether that is the principle the Russians used to achieve the same result?

Dr. SILVERSTEIN. I can only guess at this. I do not think so. I do not think they have done this yet. This is just a guess.

Dr. GLENNAN. There is no reason why they should not do it.

Dr. SILVERSTEIN. Not if they develop the technology. I do not know whether they have.

Mr. OSTERTAG. They have developed a rocket with the potentials or the thrust or the power that your SATURN hopes to achieve. Is that not right?

Dr. SILVERSTEIN. No. Our guess is that it is about—perhaps half the size of the SATURN.

General OSTRANDER. This is 1.5 million-pound thrust, theirs, we think, is probably in the neighborhood of 600 to 800.

Mr. OSTERTAG. You will pass them when you get the SATURN unless they develop something else?

Dr. SILVERSTEIN. I expect they will make progress, too.

Dr. DRYDEN. ATLAS AGENA will equal what they have demonstrated; SATURN will be ahead provided they haven't done the same thing.

Mr. YATES. Does it make sense to take the position they will not make progress?

Dr. DRYDEN. It will take them some little time as well as it does us.

Mr. YATES. Has it taken them less time?

Dr. DRYDEN. I don't think so. They started 4 years earlier.

LIQUID PROPELLANTS

General OSTRANDER. I would like to turn to the liquid propellent program. This program includes a development of three engines which appear in our future vehicles. One of these is the 1,500,000-pound thrust single-chamber engine, which I mentioned previously; the second is a 200,000-pound thrust, liquid-oxygen engine, which will be used in later versions of the SATURN, and finally, the 6,000-pound storable propellent engine, which was initiated as part of the VEGA program and which we are continuing.

Taking first the million and a half pound thrust engine, this is nearly 10 times the thrust level of any single chamber rocket engine that is presently developed. It will potentially provide propulsion for lower stages of manned space vehicles beyond SATURN. If we decide to go to something like the NOVA concept, by clustering four to six of these engines, we can then accomplish manned landings on the surface of the moon and return.

Mr. RHODES. Four to six NOVA ?

General OSTRANDER. Four to six of these engines. I would like to emphasize that NOVA is merely a design concept, using this engine as the basic engine. It is not actively under development and no development is planned to start in fiscal year 1961. The engine on the other hand has been under development since 1959. We have had tests of this engine at thrust levels above the 1 million pound mark. They were done at Rocketdyne's facility at Santa Susana, but our facilities limited us in both thrust level and thrust duration. We do have some stands under construction or modification at Edwards Air Force Base.

We will have the first full thrust test of this engine at Edwards in the spring of 1961.

The next picture I believe shows a photograph.

Mr. THOMAS. Do you have facilities at Edwards to test that engine?

General OSTRANDER. These are under construction now, sir. We have some stands which we are modifying, will take this engine or its components.

Mr. THOMAS. At Edwards?

General OSTRANDER. At Edwards Air Force Base, yes, sir.

Mr. THOMAS. Are you building these test stands all over the country? You have them in Huntsville and you apparently have some on the Pacific coast already.

General OSTRANDER. We have no engine——

Mr. THOMAS. You have them at Canaveral.

General OSTRANDER. These at Canaveral are all actual launch stands. The test stand at Huntsville is designed to take the entire SATURN vehicle fired as a vehicle.

These stands at Edwards are purely for the development of the engine itself.

Dr. DRYDEN. These are existing stands, Mr. Thomas that are being modified to take this larger thrust.

Mr. THOMAS. When were those stands at Edwards built?

Mr. HORNER. The first one we are occupying was built and occupied in 1955 as an ATLAS system test stand.

Dr. DRYDEN. It is across the lake. You may have been there.

General OSTRANDER. This photo merely shows a mockup of this engine, showing you the size of it in comparison to man.

Dr. GLENNAN. I have seen that unit fired at 1,080,000 pounds of thrust and the tongue of flame that licks out from it licks out 100 or 150 feet. You want to be in the next county. It is a really terrifying sight.

Mr. THOMAS. Where was it fired?

Dr. GLENNAN. At Santa Susanna. It was a 3½-second uncooled chamber run.

General OSTRANDER. I do not have a picture of the 200,000-pound thrust liquid oxygen engine that I mentioned. It will be used in upper stages of future versions of the SATURN and will give us roughly double the payload capacity of equivalent stages using oxygen and kerosene.

Turning next to this 6,000-pound thrust engine, it was originally started as a part of the VEGA vehicle development and it is being continued because of its continued usefulness to us in some other vehicle programs. The advantage of so-called storable propellants is of course the fact that you can carry them over long distances and over long time periods without loss due to evaporation.

We would use this 6,000-pound thrust engine primarily for upper stages in planetary orbit or planetary landing missions and for trajectory corrections during the course of the flight.

Turning now to our nuclear engine that you mentioned, Mr. Chairman, this is an artist's concept of a so-called nuclear heat transfer rocket. The nuclear rocket differs from the chemical rocket in that a nuclear reactor rather than a chemical combustion reaction is used to heat the working fluid, which in this case is hydrogen, and which then expands through the nozzle, providing thrust.

Mr. THOMAS. Where is this engine being developed and by whom?

General OSTRANDER. The reactor itself is being developed by the AEC, by their Los Alamos Laboratory. We have certain responsibilities to support them in that program, including nonnuclear components of the engine. We are also supplying the hydrogen propellant for their test program. They will go through a program to the point of a breadboard engine system. By that I mean a system which contains all of the principal components but which are not necessarily packaged as flight gear nor are they flight weight components.

Mr. THOMAS. How will the research unit in Cleveland fit into this program?

General OSTRANDER. At the Plumbrook facility?

Mr. THOMAS. Yes.

General OSTRANDER. That is primarily a basic research organization rather than a development organization. They will back us up in some of the basic knowledge that we need for the development of the engine, but the prime job of developing the reactor hardware itself is the responsibility of the AEC.

Mr. EVINS. How long has AEC been working on this?

General OSTRANDER. On the ROVER project, about 3 years.

Dr. DRYDEN. At least that much.

Mr. HORNER. They had studies much before that time but the major development effort in terms of funds being applied to the project has been during the last 3 years.

Mr. OSTERTAG. Do you actually hold out belief that nuclear power can be employed in rockets?

Mr. HORNER. They have had a ground test, KIWI test device using this cycle, which was very successful. This was last summer.

General OSTRANDER. I think that the theory of the operation has been pretty well proven. It is merely a matter of further development.

Mr. OSTERTAG. That is not true in connection with the missiles, is it?

Dr. DRYDEN. There is some question about whether you want to use it in all stages, particularly the first. We have to test the engine now as though it were a bomb; in other words, at the AEC's Nevada test site. The nuclear rocket engine is putting out radioactive material. We think the first use of it would be in upper stages where you do not start up the reactor until it is out in orbit.

Mr. EVINS. You have used nuclear power in other cases. Why cannot you put it in a rocket?

Dr. DRYDEN. You cannot afford to carry that much shielding in a rocket, but in an unmanned space vehicle you can use nuclear power without any or with only a small amount of shielding.

Mr. BOLAND. In the development of nuclear missiles, what is the name of that project?

General OSTRANDER. This is the ROVER project.

Mr. BOLAND. Is this being developed by the University of California?

Dr. DRYDEN. You are thinking of project PLUTO.

Mr. BOLAND. Is that the ramjet? What is the difference between that project and the ROVER project?

Dr. DRYDEN. It is an air-breathing vehicle which works in the atmosphere.

Mr. HORNER. Instead of using liquid hydrogen to cool the reactor, it operates like a ramjet and takes in air and the air goes through the reactor and is heated.

General OSTRANDER. In the case of the rocket you actually have to carry along a working fluid, which is equivalent to fuel and it is heated by the reactor and expanded through the nozzle, but you can only operate it as long as——

Mr. EVINS. Do you have a target date set for a nuclear rocket test?

General OSTRANDER. No, sir; we do not as yet.

Dr. DRYDEN. Not for the flight test. There is a target date set for the ground, or breadboard, test.

Mr. EVINS. Is the delay yours or the Atomic Energy Commission?

General OSTRANDER. The breadboard test is the responsibility of the AEC.

Dr. DRYDEN. The delay is due to the problem of how to design it. It is a little difficult to design a test vehicle without knowing more about the weight and shape of the engine.

Mr. EVINS. I am talking about the Atomic Energy Commission. They say they will have atomic power in the next 15 years and that they already have it in New England.

Dr. DRYDEN. They are, of course, developing the reactor end of this. They are not in the flight vehicle business. A test flight on this rocket can be made with SATURN after the 11th vehicle availability which has been referred to, in about 1964 or 1965. The use of it in an operational space mission will probably come about the end of the decade.

Mr. YATES. You indicated that you cannot use this for the first stage.

Dr. DRYDEN. I did not say you cannot. If you do, you have to treat it like a bomb. You have to launch it at some place where there is plenty of area and protection and at some place where the personnel is thoroughly protected. You would also have some atmospheric contamination which would stir up a lot of political problems. These problems do not arise if you use it in space itself.

Mr. BOLAND. I would think that the shielding problem would be terrific.

Dr. DRYDEN. You could put shielding on the ground to protect the launching personnel, but you cannot put shielding on the rocket which would protect people elsewhere from the air which would be contaminated as the rocket passed upward through it.

Mr. EVINS. What about shielding the man for the "Man-in-Space" project?

Dr. DRYDEN. There is some question as to whether we can use the nuclear rocket for manned flight.

General OSTRANDER. We are not completely out of the woods on the shielding problem even if you do not have a man in the payload. This radiation has some effect on the components of the vehicle itself.

Mr. BOLAND. On the nuclear powerplants you have to shield the reactor, the crew, and the plane, and then you will have to shield the field itself.

Mr. YATES. The plane just does not get off the ground.

Mr. BOLAND. If it is ever gotten off the ground, it would be easy to bring down.

General OSTRANDER. Another area of nuclear technology that we are working in is auxiliary power generation. We are working on several different kinds. There are actually machine-driven systems where a nuclear reactor actually drives a nuclear-powered turbine and this is used, in turn, to drive an electric generator, or we may have systems to convert the input energy to electrical power directly without a machine. This is the system used in the so-called "Snap–3" power generator.

SPACE POWER TECHNOLOGY PROGRAM

Turning next to the so-called space power technology program, this covers two general broad areas: The first is electrical propulsion—actually making use of electrical particles to propel a vehicle—and

the other is auxiliary power generation by means other than nuclear reactors.

The objective of the space electrical propulsion is to find means of actually accelerating electrical particles so that they give thrust to a vehicle. One example, of course, is the ion accelerator. We focus a stream of charged particles and they are made to leave the unit at extreme velocities up in the order of hundreds of thousands of miles per hour. The specific impulse of the electrical rockets is very high, something like from 2,000 to 20,000 pound-seconds per pound. This is in comparison with 450 pounds that we are talking about in hydrogen-oxygen systems.

On the other hand, because of the small amount of mass that can be acted on with the available power, the total thrust is low. The thrust that can be produced is about one-ten-thousandth of the total weight of the apparatus on the ground. These are useful only for propulsion where you are in space and you want to accelerate slowly over a long period of time.

In our space technology program we also have nonnuclear power generating units which we hope to use to replace chemical storage batteries where we need power extending over longer periods of time than the batteries will give us. Since solar energy is the energy which is most available in space, much of our work is connected with attempting to focus this extremely thin energy and concentraing it to do useful work.

We have bids to develop a 3-kilowatt solar auxiliary power unit, and in this case the radiant energy of the sun is focused by this mirror on this boiler in which a liquid metal is used to drive a turbine.

Mr. THOMAS. If I may interrupt you has not Dr. Abbott over at the Smithsonian been working on this for a long time? Does he not have a laboratory somewhere?

General OSTRANDER. This boiler, in turn, drives a little electrical generator.

Mr. THOMAS. Is he not located in New Mexico? How is he doing?

Dr. DRYDEN. He has made a solar stove, I think.

Mr. THOMAS. Are you using the services of the good doctor in this research?

Dr. DRYDEN. Not directly.

Mr. THOMAS. For 25 years he has been fooling with the sun's radiation, trying to convert it to heat.

Dr. GLENNAN. They have an institute on solar research at Tucson.

Mr. THOMAS. Are you using that institution there?

General OSTRANDER. I do not believe we are; no, sir.

Mr. HORNER. These are all industrial contractors that are bidding on this program. This is a contract that is out on bid.

Mr. THOMAS. What do these people know that that research institution does not know? They have been working on it for 25 years.

Mr. HORNER. Much of the research from that institution has been published in the form of reports and has been made available to these industries. Basically, the problem is converting the technology to hardware.

Mr. THOMAS. You are trying to build the gadget?

General OSTRANDER. Yes, sir, we are trying to figure out what kind of material to use for the reflector and determining what kind of liquid metal we would use in our boiler.

Mr. THOMAS. How much are you spending on this gadget?

Mr. OSTERTAG. Is the theory or principle involved that the elements would provide the power?

General OSTRANDER. The sun's rays are concentrated on this boiler and they provide the heat energy to drive the generator.

Mr. ULMER. There is the sum of $2.1 million involved.

General OSTRANDER. We had $1.6 million on this in fiscal year 1960 and $2.1 million requested in 1961.

Mr. THOMAS. $1.6 million in 1960 and you are requesting $2.1 million this year?

General OSTRANDER. Yes, sir.

Mr. THOMAS. You may proceed.

General OSTRANDER. The only thing I have left——

Mr. THOMAS. Who is your contractor here?

General OSTRANDER. We have not selected one as yet. We have requested bids.

Mr. THOMAS. You mean your 1960 funds are not obligated yet?

General OSTRANDER. No, sir, but they will be by the end of the fiscal year.

I have only two remaining charts, Mr. Chairman, which sum up the distribution of the funding.

VEHICLE DEVELOPMENT PROGRAM

Within the vehicle development program—I do not know whether I mentioned it—but in the case of the SCOUT we have essentially completed this development and we are requesting no money for 1961.

These [indicating] are the other programs that I covered. I think I mentioned that in the Agena B program the development costs are covered in the Air Force program. Therefore, we have no money in our vehicle development program for these items.

The cost of modifications to give us a vehicle necessary for our program is carried in our mission line items under Dr. Silverstein's program. Here I should point out that in the case of the SATURN, because this is essentially an inhouse program at Huntsville to date as opposed to a contractual program, I have shown not only the research and development cost but the other costs at Huntsville directly identifiable to the program.

Mr. OSTERTAG. You do not show NOVA.

General OSTRANDER. No, sir; the NOVA program consists only of this F–1 engine development and this is shown next.

Mr. THOMAS. Who else do you have? You have Dr. Silverstein and Mr. Abbott. We heard Dr. Silverstein this morning. We heard what he had to say.

You may proceed, General Ostrander.

General OSTRANDER. This is all I have, sir. This summarizes the distribution of the funding in the advanced technological program which I covered.

Mr. THOMAS. All of these statements are in the justifications almost verbatim. I have read them once. What is Dr. Silverstein going to tell us that is not in the justifications?

Dr. GLENNAN. I think a very exciting story.

Mr. THOMAS. It is not in the justifications?

Dr. GLENNAN. Some of the words are there but the feeling that I think he would put into it is not in the justifications.

Mr. THOMAS. What is Mr. Abbott going to tell us?

Dr. GLENNAN. About the research centers and the program in aeronautics as well as the programs that he has been undertaking in support of materials development and missiles.

Mr. THOMAS. How are we going to squeeze them into this hearing in 20 minutes?

You may proceed, Dr. Silverstein.

STATEMENT OF THE DIRECTOR, OFFICE OF SPACE FLIGHT PROGRAMS

Dr. SILVERSTEIN. Basically, Mr. Chairman, my presentation is in answer to your question of this morning on what our program might be for the next several years and to basically highlighting the program that is outlined in our budget presentation.

I thought it would be desirable to group together these flights, showing what we intend to do and, basically, what we intend to learn in our oncoming flights.

SOUNDING ROCKETS

Dr. Dryden mentioned this morning that we do find it necessary to carry on a program in sounding rockets. This is the first step in a deep space or a satellite program wherein we in the laboratory develop new ways to measure things and find out how to measure magnetic fields in space or the radiation in space. People conceive ways of doing this and we start with our sounding rocket flights by putting these aboard relatively inexpensive vehicles and flying them up to high altitudes and finding out whether, in fact, they do operate the way they are intended to do.

Furthermore, there are many measurements which we wish to make which require that we take a vertical cut up through the atmosphere, and this can best be achieved with a sounding rocket. So, our program includes, and is detailed in our budget presentation, a series of sounding rockets in these various fields of atmosphere, ionosphere, energy particles and so forth.

During the year 1961 we are intending to fly some 100 of these rockets. These rockets, on the average, cost from $25,000 to $30,000 each to fly. Within the framework of this some cost more. The ones that go to higher altitudes are more expensive and some aimed particularly at the meteorological field will cost less.

EARTH SATELLITE MISSIONS

We now look to the program which we call our earth satellite missions. Let me say here in a general sense that our program has three basic ingredients in it: One is a scientific program of the exploration of space. We are trying to find out what is in the universe that we ought to understand before we go too far. We cannot hope to fly men in space unless we understand the conditions of radiation in space. More than that, we would like to understand something about the universe. We would like to know what the history of the universe has been. Naturally, to understand some of the fundamental

laws of the universe so they can be applied for the benefit of man we feel over the past has led them out of the caves——

Mr. THOMAS. Doctor, let me interrupt a minute and cut you off. We have just built a big laboratory for our mutual friend—and he is a friend of yours—over here in West Virginia. He is a very able physicist and he has some big dishpans over there and he is taking a look at the sun and the moon.

There is no need of fooling with that. We are going up there and actually walk around. We do not need this thing downstairs; do we?

Dr. SILVERSTEIN. There are things that he will learn that we will not learn and there are things that we will learn that he cannot learn.

Mr. THOMAS. What is he going to see up there that you are not going to experience when you get there?

Dr. SILVERSTEIN. He has a capability with his big dish of observing very distant space radiation and certain wavelengths. He is shut off from observing certain wavelengths in the ultraviolet field and, in fact, except for a few windows, he is shut off from observing many things.

Mr. THOMAS. You are going to send a man up there, and your justification states the reason for sending him up there is that he is going to have his senses with him and see all these things.

Dr. SILVERSTEIN. When you have a dish the size of the one there in West Virginia, you know the receptive capability is the function of its area. We are certainly not for some time going to be able to carry dishes of that diameter into into space and be able to pick up the very faint signals that he will be able to intercept in the ranges of frequency that he would be able to record.

Mr. THOMAS. But, he is getting his information secondhand. You will have men up there in space and we get it firsthand. So, we do not need that dish any more. You do not have your big booster ready yet but you will have it ready in a couple of years and then we will be all set.

Dr. SILVERSTEIN. I would say we do need it and I would say even more than that it will be quite helpful later in our program.

Mr. THOMAS. That is the answer I was expecting. How will it help you in your program?

Dr. SILVERSTEIN. It will have the capability of receiving signals far out in space and we will probably be knocking at his door in the future asking for help in receiving the signals.

Mr. THOMAS. You have some money in here to improve your signal business too.

Dr. SILVERSTEIN. Yes, sir.

Mr. THOMAS. How is he going to help you on that?

Dr. SILVERSTEIN. As I say, the receptivity of the dish to faint signals is a function of the area of the dish and the quality of its surface. He will have a big dish which will be a very fine surface and this will be of great help.

Mr. THOMAS. On a signal basis only for reception of signals?

Dr. SILVERSTEIN. Yes, sir.

Mr. THOMAS. Beyond that he will not have too much utility in the future will it?

Dr. SILVERSTEIN. In his field in radio astronomy it will have a great usefulness.

Mr. THOMAS. How?

Dr. SILVERSTEIN. The radio astronomer's work is trying to map out the history of the galactic systems, based on observations of their reception from the stars.

Mr. THOMAS. One of the many things we can put our finger on that you hope to accomplish in this whole program is the field of communications?

Dr. SILVERSTEIN. Yes, sir.

Mr. THOMAS. How is he going to fit into that program with his big dish?

Dr. SILVERSTEIN. I do not quite see how he fits into that program. He fits, rather, into the program of scientific exploration of space.

Mr. THOMAS. Well, virtually will you not be many, many jumps ahead of him if you get a man in space?

Dr. SILVERSTEIN. We will have trouble getting a manned systems that will be able to have as big area of reception as he will have for some time to come. We will not visualize things in this area as yet in our program.

Mr. THOMAS. In other words your payload will not be big enough for a few years?

Dr. SILVERSTEIN. I think so; it will be a little small.

This [indicating] is a program of earth satellites. It includes these three phases I introduced: The exploration phase, the phase of the application of satellites to problems such as communications and meteorology. Both these applications, we think, are very important to the future economic life of our country. In addition we have our manned space activity and all of these are in the satellite field.

This chart shows the scientific experiments in progress—the communications in green and the meteorological in red—and outlines the program for the next several years ahead.

You might ask why have we gone this far in this program? It is because of the lead time item that Dr. Dryden mentioned. We must look ahead and provide funds in fiscal 1961 in order to handle the projects that we intend to use in 1963.

In this program in the next year we will be completing our work with the JUNO II vehicle with four satellites: The meteorological satellite marked "M," with the THOR–ABLE, which is the one we intend to fly about the first of April in which we will send a satellite to take weather measurements.

In the SCOUT program we show a number of firings for the next several years, and I will outline those in more detail, and the same thing is true on the DELTA. We have a communications experiment which we intend to get off soon using a large balloon and using the new DELTA vehicle which General Ostrander outlined previously.

So, we go to the THOR AGENA–B which we will fire sometime in fiscal year 1962. However, in the meantime we must prepare this satellite payload in our laboratories and in the contractors' shops to have it ready at this time. The same thing is true of the flights of ATLAS AGENA–B which will be flown in fiscal year 1961.

I will show in more detail what they are to be used for.

We have here [indicating] a flight of a JUNO II scientific satellite in the third quarter of fiscal year 1960. This is a flight that currently is scheduled and it will be an extension of our radiation belt studies. Experiments have been prepared at Iowa State and are up to date versions of the radiation experiment that I mentioned earlier, using the first EXPLORER vehicle. Since that time, after looking at the data, we have been able to determine the ranges of the instruments better and have new and improved instruments aboard this vehicle for this flight.

In the same way we will continue working in the ionosphere and gamma and cosmic rays. This will be the first time we will make measurements of gamma rays in space, and here [indicating] we have one with the ionosphere beacon, the DELTA scientific satellite program.

VAN ALLEN RADIATION BELT

Mr. THOMAS. Just a minute, Doctor. Dr. Van Allen has a big question mark about whether you are going to be able to get through his radiation belt up there with your astronauts. Has he not expressed some doubt to that effect?

Dr. SILVERSTEIN. Yes, sir.

Dr. DRYDEN. They are not scheduled to go that high.

Mr. THOMAS. His first radiation belt is not too high up as distances go.

Dr. GLENNAN. 600 miles.

Dr. DRYDEN. It is quite a bit beyond the 120 miles that we will use in the first astronaut's flight. It is well beyond that.

Mr. THOMAS. But, you plan to go much higher than that later on, do you not?

Dr. DRYDEN. He is talking about when we try to send a man out to the moon and come back.

Mr. THOMAS. I though he indicated you would have trouble getting a human being through that first band.

Dr. DRYDEN. No. Van Allen says the man can get through but you cannot keep him in it very long.

Mr. THOMAS. He thought we could get him through without damage?

Dr. DRYDEN. Yes, but you cannot keep him there very long.

Dr. SILVERSTEIN. In our MERCURY flight the man will fly at an altitude of about 120 statute miles and here there is no real great difficulty with the radiation belt because it is not the center of the lower radiation belt.

Mr. THOMAS. The first band is what? Is that 600 miles?

Dr. DRYDEN. Over the Equator; it extends from 600 miles to over 2,500 miles.

Mr. THOMAS. And, it is 15 or 20 miles thick?

Dr. DRYDEN. It runs all the way from 600 miles to 2,500 miles or more with different particles reaching their maximum at different levels.

Mr. THOMAS. What was his second band?

Dr. DRYDEN. What has been called Van Allen's second band extended from 10,000 miles to about 35,000 miles over the Equator. But you must remember that what an experiment detects depends on what

his instruments "see," as it were. The instruments from which Van Allen's data came had a threshold of sensitivity such that they showed an inner and an outer zone just as he has described them. But later observers with different instruments, measuring particles of different energies than those observed by Van Allen, have seen a different structure in the radiation belt. In general, then, one should think of the radiation belt as a great diffuse region of highly energetic particles trapped by the earth's magnetic field, and which may show various zones depending on what the instruments being used are able to detect.

Mr. THOMAS. It depends upon the way you look at it. It could be one band 200 or 300 miles thick.

Dr. SILVERSTEIN. Actually, the second band is considered to run from about 10,000 miles to about 35,000 miles. That is a pretty thick band at the Equator.

Mr. THOMAS. I would not want to go through that on foot anyway.

Dr. SILVERSTEIN. In the DELTA program I think you saw an outline of it which is coming into use this year. We have a range of experiments here involving solar spectroscopy in which we point an instrument at the sun and measure the spectrum of the sun with this pointing instrument.

We continue our radiation belt studies with an advanced group of instruments and study the atmospheric structure and send a satellite around the world with a flashing light so as to do a study of a geodesy of the world and world and work here on the ionosphere topside in 1962 and we are about on time.

Now, our SCOUT vehicle is coming along and again during the period we have a series of satellites listed for its use, and in this grouping are the satellites to be used in the international program, the program in which Great Britain will provide the instruments and we will fly the satellites.

Again, you will see that some of these vehicles are flown on polar orbits from the Pacific missile range, flown so as to go around the world from north to south and thereby give us this coverage of the whole range of the latitudes.

Going ahead in the program we come to the payloads that will be carried on the AGENA vehicle. Here we show both the use of the THOR–AGENA that you, again, were reminded of in the previous chart and the ATLAS-AGENA.

Here is a class of quite heavy payloads that will weigh upward of 5,500 pounds and we come into the range of where we can actually develop an astronomical observatory.

Mr. THOMAS. Are your payloads being developed along with your thrusts?

Dr. SILVERSTEIN. Yes, sir; that is the purpose of our budget. Development here is to provide the funds needed now for these very complex payloads to be flown in later years. For example, in this astronomical observatory we have underway both the space craft that will carry these vehicles from a design point of view and, also, by contracts with numerous universities throughout the country we are working with the scientists and astronomers who have a deep interest in putting aboard this satellite the various instruments that are appropriate to their range of knowledge.

RESEARCH GRANTS AND CONTRACTS

Mr. THOMAS. Your research grants, or your description of them, is quite inadequate. I was just wondering what is your main basic new research grants. You indicate you want to go into the field of medicine and biology, but what is the main burden of your research grants now?

Dr. SILVERSTEIN. They cover a wide range of technical disciplines and scientific disciplines. If you read through the entire list of them, you will see that they cover almost all of the areas of the physical sciences that we are working in.

Mr. THOMAS. Your predecessor agency had anywhere from $500,000 to $750,000 for that purpose. Here you want to jump up to $10 million. What fields are you going to broaden?

Dr. SILVERSTEIN. Well, our fields are quite a bit broader now than they were before. For example, this is a good case in point right here in the astronomical observatory. We have scientific people, for example, at practically all of the important universities—the California Institute of Technology, the California University in Berkeley, Calif., Yale, and Harvard—people who are working in the field of development of the types of sensors or the astronomical instruments that we will want to use in this observatory.

These contracts are expensive because they are essentially developing prototype equipment. As soon as they get through the prototype and breadboard type equipment we will go into contracts for actual development of the hardware.

METEOROLOGICAL SATELLITE TIROS

Now, I pointed out that our program includes application satellites and one range of application in meteorology. I think we told you before that it is of considerable interest in our program to see if we can develop systems for observing the weather throughout the world and currently we have developed this payload, which will provide us television pictures with two different cameras, both a wide-angle TV camera and narrow-angle camera—pictures of the cloud cover over the entire world. This satellite is to be fired within the next quarter and we are hoping if it is successful to be able to transmit back to the ground to a certain command station or stations distributed throughout the world, information regarding cloud cover over the whole surface that this covers and also to get our first real understanding of how far we can go in this field of meteorology. In other words, from these measurements we will be able to size up the possibilities for the use of satellites in the meteorological field.

We have made arrangements with the Weather Bureau to carry on analysis of the data. We are tied in with all the principal agencies in the country who are interested in weather. The military services of course are interested. We are working with the Cambridge Center and sending the data to them.

We would hope that with this satellite and a followon satellite which we will have next year, to get our first real understanding of the possibilities of the satellite in the meteorological field.

In the same way, we are beginning our work very shortly in the field of communications, another field of application of the satellites. Here many people have estimated it is possible if we use satellites in the communication area, and almost everyonew ho has looked at it seems to feel there is a very important area here for development.

Mr. THOMAS. Doctor, you are making a very interesting statement. Let us come back at 10 in the morning. Then you and Dr. Abbott will finish your statements. We will then go into your justifications.

TUESDAY, MARCH 15, 1960.

Mr. THOMAS. Will the committee please come to order. When we adjourned yesterday Dr. Silverstein was making a very able and interesting talk. Proceed, Dr. Silverstein, and use all the time you want.

Dr. SILVERSTEIN. I was discussing the meteorological satellite TIROS, which as I mentioned will be placed in orbit with a THOR-ABLE vehicle. We will put this into about a 380-mile orbit, and it will take TV pictures of the cloud cover over part of the orbit it covers. We will expect to have later in the year a second TIROS package available for flight.

Mr. THOMAS. What will be the weight of your first and second packages?

Dr. SILVERSTEIN. The TIROS package weighs around 160 pounds. Our following program, however, will include new instrumentation and will be a heavier package, shown on the next chart.

METEOROLOGICAL SATELLITE NIMBUS

We have an oncoming program of a vehicle called NIMBUS which is the followon meteorological program. The first of these vehicles will carry this package weighing around 600 pounds, will be put in about a 600-mile orbit around the earth, and make a TV coverage of clouds. It will have a very excellent instrumentation for measuring infrared radiation from the clouds to the satellite.

One of the interesting differences between the two satellites, the TIROS and the NIMBUS, is associated with the way they are oriented. The TIROS satellite, of course, will be launched from the THOR-ABLE vehicle with a spinning top stage and will maintain its orientation in space as it goes around the earth along the same spin axis that it is launched with. The second one will have a stabilization system in it that is always orienting it toward the center of the earth. This is done by means of a gas jet system, and a sensing system to tell its position. The gas system then reorients the position of the vehicle so it aims directly at the earth's surface.

There will be two NIMBUS firings during the 1961–62 time period, and at the end of this time period we believe we will be far enough along with the program so we will be able to outline the methods for establishing something that might be called an operational meteorological system. By this we hope to establish the groundwork in these early flights for collection of data, meteorological data, that can be forwarded to a central meteorological center that will reduce the data and make it available throughout the world at a station such as our World Meteorological Center.

COMMUNICATIONS

Now in addition to our work in meteorology, we are working with communications, and again we have an early flight planned. We are going to place in a satellite orbit a 100-foot sphere. This sphere is made of about one-half-thousandths-inch Mylar, which is a plastic, and is contained during the firing within a 26-inch sphere. This plastic sphere is folded and compressed in a small diameter aluminum sphere, fired into orbit, at which time it is released from its sphere container and inflates. The inflation comes about as a result of the air left in the sphere during its compression into its package, and materials we put inside the sphere to sublimate at high altitude and low pressures and provide a gas to fill the sphere.

We have been making preliminary shots with sounding rocket vehicles using this package, checking it and determining whether or not it will inflate properly. We are beginning to understand some of our problems here and think we have it under control and expect our flight has a good chance of success.

This chart [indicating] shows a picture of the sphere. The diameter from the floor to the top is 100 feet. You can get a feeling of the size from the man shown at the bottom. The sphere when it is in orbit will be used as a target for transmitting stations on the ground to bounce from it radio signals which will be received at a distance. In our network currently we have a transmitter and receiver at Holmdel, N.J., and also one in our station at Goldstone on the west coast, and we will send a signal from Holmdel, bounce it off the sphere, and receive it at Goldstone, the distance across the country. Now, this program will be continued for the next several years. We expect to have perhaps one more firing of this sphere during this year, and are looking forward to placing in orbit a number of these spheres so we can provide for continuous communication around the world. We can also, in addition to bouncing signals from the ground to the sphere, carry signals and relay them from one sphere to the next, and by establishing a series of these around the world we can get around-the-world communications of a broad band character. We would expect to be able, for example, to have a bandwidth that would enable the television signals to be relayed around the world.

MOON, DEEP SPACE AND INTERPLANETARY SPACE PROGRAM

Now, these two programs that I have been discussing are related to our work in applications of satellite systems for useful economic purposes. We have, as you know, a very strong program aimed toward investigations of the moon, and deep space and interplanetary space. This program has been making excellent progress. Our firing of last week was one firing in this group of firings.

Here we list on this chart [indicating] the program we have laid ahead for the next several years. The "I" refers to interplanetary flights; the "L" lunar flights, and the "P" planetary flights. The one shown in the third quarter of the fiscal year 1960 is the one we have just accomplished.

We are planning to use a DELTA vehicle to send a probe aimed toward the sun, and here we will include instrumentation for study of the sun itself and the plasma field around the sun. As you will recall

we had two failures of the ATLAS-ABLE vehicle last year, one of which was on Thanksgiving Day when we were attempting to put a 350-pound payload package in orbit around the moon. We are continuing this series of flight tests this year, and the flight is planned currently for some time this year when we will use a package quite similar to the one we attempted to fly last year, and we will use the same vehicle. These two firings are shown in the blue during the first and second quarters of the fiscal year 1961.

In the fourth quarter of 1961 we are planning to introduce into our program the first of the vehicles aimed toward impacting the moon. You will recall that General Ostrander mentioned the ATLAS AGENA vehicle in his presentation yesterday. This vehicle will enable us to build a payload package with a weight of about 600 pounds that we can use to send in the vicinity of the moon. We will follow our first flights, which will be experimental flights of the vehicle and the payload to check out the systems, with other flights during the fiscal year 1962 as shown here [indicating], and an interesting feature of this payload is that it will have aboard a special vehicle system designed so that we can allow it to be discharged from the main satellite and it will impact the moon with instruments to measure perhaps the seismic motions on the moon, its temperature, and some of the radiation on the surface of the moon.

Mr. JONAS. Is it because the fall months are most acceptable that you are waiting nearly a year to try the next lunar shot?

Dr. SILVERSTEIN. No, sir; that is not the reason. As a result of our sounding rocket program, we have been studying the characteristics of some of these rocket systems we are using, and one of the things we have encountered in our studies—information on the top stage rocket that we use, the so-called 248 rocket—is that it has a very high vibration force that it puts on the payload.

Mr. JONAS. Do you need this additional time?

Dr. SILVERSTEIN. Yes. We have just received this information in the last several months, and we feel it is hazardous to fire our existing payload on that rocket now. What we have done basically is to go back and specify the design requirements of that payload in terms of the information we have now. This requires a new environmental test of the package. It will require some redesign of the structure of the package. We do not want to fire this until we are assured it will not break up in flight. It is too expensive a package to take a chance on it so we are going through the exercise very carefully. The contractor cannot complete this work to fly before August.

During fiscal year 1963, and particularly in calendar 1962, the opportunity arises for a flight to Venus and Mars. Now for these flights we are bringing into use for the first time the CENTAUR vehicle. As you know, the CENTAUR vehicle is scheduled to fly first in 1961. This is a vehicle which will give us a payload capability almost twice as large as ATLAS AGENA, and will enable us to take a payload of about 700 pounds out into interplanetary space. We are currently working on the design of this payload, and we would hope that in 1962 we will be able to fire successfully to the planets Venus and Mars.

This summarizes the lunar and planetary missions that we have in this time period.

We will now go to the next chart. I think you will be interested in seeing what some of these spacecraft look like that we are going to use in these flights. Although this [indicating] is an artist's drawing, it is a reasonably accurate representation of the payload we are currently designing for this ATLAS AGENA flight which is to impact the moon.

You see the space craft leaving the earth here [indicating], coming toward the moon with its radio antennas stretched out for both transmitting and receiving command signals from the earth. These [indicating] are the solar paddles. The counterbalanced weights are here [indicating], and what we have here in the middle is the vehicle we will use to impact the moon. This spacecraft is moving toward the moon probably at some velocity close to 7,000 feet per second, and if it were allowed to come in it would simply destroy itself on the surface of the moon. However at some point out in space here we will fire backwards to kill the velocity that this central segment has acquired in accelerating toward the moon and therefore reduce the speed of the impacting body so as to make it possible to survive on its impact on the moon's surface. As we approach the moon we will fire a rocket here backwards, away from the payload, and thus slow its relative speed with respect to the moon.

Mr. JONAS. A concept of putting on the brakes.

Dr. SILVERSTEIN. It is a way of putting on the brakes.

Mr. RHODES. When will that be?

Dr. SILVERSTEIN. 1961.

For our CENTAUR flight we have the general configuration of the vehicle which will be quite similar to that of the AGENA. It will be larger and heavier, and will require that we carry along higher wattage transmitting equipment and more technical equipment to assure success of the flight from the standpoint of guidance and terminal flight characteristics. This spacecraft is currently under design. It requires a long leadtime to produce this equipment. It is expected there will be about a 3-year leadtime to actually go through the development required to produce this spacecraft.

Mr. RHODES. What do the solar paddles do?

Dr. SILVERSTEIN. The solar paddles are made up of a whole series—8,000, 10,000, 12,000—of small silicon cells, and these cells make a direct conversion of heat energy into electrical energy. It is a principle of physics. The particular characteristics of these materials are such that you can convert energy directly, and this current flows into the system that charges batteries and serves as a storage unit, and then the current is used up in the transmission and operation of instruments, and then there is a recharging period. It is a great deal like the system you have in your garage to keep your battery charged.

Mr. RHODES. How long will it continue to transmit from the moon, or from a planet?

Dr. SILVERSTEIN. Of course, this is the type of information we are trying to learn from our current flight. Our current flight is serving as a backup in a sense to these later flights in providing us answers to the question you have asked. I can only say now we have calculations of this, and we think we will be able to transmit from long distances, distances from the planets, but we do not know yet.

MERCURY PROGRAM

Now, one of our major programs, as you know, is the MERCURY program. It is a program being carried along in our organization with the highest priority. I think we have outlined this program to you recently in our supplemental hearings. I will not go into a great deal of detail now regarding the components of the system. This [indicating] is the flight schedule. We have shown here one additional LITTLE JOE flight. We have accomplished this one successfully. It was included on the chart that Dr. Dryden presented yesterday.

We have REDSTONE flights scheduled during the fiscal year 1961 which will serve to first qualify the capsule and its instrumentation in suborbital flight, in ballistic flight, and as we move along in this REDSTONE program we will reach the point where we feel the characteristics of the system have been checked out adequately and we will be able to put aboard a man. It is intended that this man will be qualified in his flights as a result of some 5 or 6 minutes of weightless flight. The REDSTONE flights, of course, are preliminary to the ATLAS orbital flights.

First, we have in our ATLAS program several flights that are suborbital. These are qualification flights of the McDonnell capsule. Dr. Dryden discussed with you yesterday the flight called BIG JOE that involved the firing of a capsule on a suborbital path and studied the heat shield and the motions of the capsule during its flight. We repeat this now with the actual final flight capsule that is being produced by McDonnell Co. in these early flights. As we move along, we will follow the suborbital flights with orbital flights shown in green here [indicating]. The flights here will qualify the equipment for longer periods of time. They will bring into play our tracking systems and provide a means for checking out our whole tracking systems. We will fly perhaps with a chimpanzee before we put a man aboard to find out whether or not there are certain physiological effects on the animals that should be taken into account before we fly the man, and then we will move into our manned flight program. If things move without too much difficulty, if we find that our engineering designs and our estimates of the situation are correct, we would hope during the calendar year 1961 we would be able to fly a man successfully in orbit.

That summarizes the program.

I have a further chart which shows the costs that are budgeted for the separate elements of the program.

Mr. RHODES. When is the first suborbital flight scheduled with a man on board?

Dr. SILVERSTEIN. Hopefully this year.

Mr. RHODES. This calendar year?

Dr. SILVERSTEIN. Yes. All of these dates we preface by saying we will not fly the man until we have suitable assurance the equipment that he will fly in is properly qualified.

Mr. THOMAS. That was a fine statement, Doctor. We always enjoy listening to you.

Dr. GLENNAN. Mr. Abbott is next. With respect to these dates for flights, we are pinpointing them only to the extent of the quarter in

which they will occur up to the next 18 months, and beyond that only with respect to the year in which they will occur.

Mr. THOMAS. You correct the record anyway you want.

STATEMENT OF THE DIRECTOR, OFFICE OF ADVANCED RESEARCH PROGRAMS

Mr. ABBOTT. I want to talk to you about NASA's advanced research activities because it is through these activities that we produce the research information that is needed to permit the design and development of the advanced vehicles about which you have been hearing, and which will be needed as the Nation's space program progresses.

We use the term "advanced research" to include the following activities:

First, the conduct of objective research to produce the technological background that will be needed for manned and unmanned exploration and use of space.

Secondly, the use of these research findings to generate new concepts for missions of the future, and finally, the provision of assistance in the application of these research findings to make sure this application is a prompt and effective one.

We provide this assistance through consultation, special studies, and specific tests while the design and development of these vehicles goes on, and provide it both to Dr. Silverstein and General Ostrander's shop within the NASA, and also to the military services and other governmental agencies.

As you know, most of this research is being conducted at the NASA research centers which were the former NACA laboratories. We are conducting there a broad program of advanced research, by far the greater part of which is directly associated with NASA's mission of space exploration and use.

Mr. THOMAS. How many laboratories are you building this year?

Mr. ABBOTT. I am afraid I do not quite understand your question. We are not building any laboratories. We have the four research centers with which you are familiar. We are in the program for about $21 million worth of new construction at these research centers.

Mr. THOMAS. You call them laboratories in your justifications. You are building one at Goddard. You are building one at Huntsville and you are building one down at Langley.

Mr. ABBOTT. I am talking specifically about the research centers—Langley, Ames, Lewis, and the flight research center.

Mr. THOMAS. You are asking for new laboratories to evaluate the research effort before you turn it over to the two operating groups.

Dr. GLENNAN. I think we are building two so-called laboratory buildings at Lewis and two more at Langley.

Mr. ABBOTT. Yes; there are four major pieces of construction.

Dr. GLENNAN. I am speaking only of the ones where he has responsibility.

DISTRIBUTION OF RESEARCH EFFORT

Mr. ABBOTT. Well, we are continuing, however, to carry out our responsibilities to conduct research to support and guide our Nation's activities in aeronautics and missiles. The aeronautical research, however, has been greatly reduced. This reduction reflects the chang-

ing emphasis and importance of military programs from aeronautics to missiles and other activities. This reduction is also in accordance with the growing capability of industry and other governmental agencies to conduct certain kinds of research for which the country formerly looked primarily to the NACA. At the moment our research, as I said, is primarily associated with the NASA space mission.

Mr. THOMAS. Are you still using 25 percent of your assets and manpower and dollars in your laboratories in research for aviation?

Mr. ABBOTT. This next chart shows the distribution of the research effort at the research centers on December 15, 1959.

The data on this chart are from a special survey which was conducted on that day. On December 15 we sent a telegram to each of the research centers asking them to analyze the time charges of every man in the center with regard to the applications of the research, using the headings shown on this chart [indicating].

Now, a great deal of judgment is of course necessary to assign the most probable application for the research. This is especially true in the more fundamental research areas where the final applications are frequently not at all clear. However, the research people themselves who made this assignment are I believe the people who are best able to do this.

This summary shows that as of that day over two-thirds of our effort was directly associated with NASA's space mission; something over one-fifth was connected with manned aircraft and about 11 percent on missiles.

Now the type of work we are doing on missiles these days, which is primarily in connection with ballistic missiles and antimissile missiles, is very closely connected with the space mission work; in fact, researchwise it is hardly distinguishable, so we have about four-fifths of our work in connection with the space mission and about one-fifth left for manned aircraft.

Mr. OSTERTAG. In connection with missiles, where do you and the Defense Department come together on this? After all, they are involved in research in missiles. Where do you stop and they pick up?

Mr. ABBOTT. We still are doing to this small extent exactly the same type of work as the NACA did for the Department of Defense. We have special skills and special facilities which other people do not have, and we use these to help out the Department of Defense in regard to special problems they encounter, and also, looking into the future, to obtain information for the guidance of their work. This has been going on, as you know, for over 40 years, and it has worked out extremely well. Most of our manned aircraft research activity is of that same type.

Mr. OSTERTAG. Are you involved in the B–70 also?

Mr. ABBOTT. Yes. We are supporting the B–70.

I think it is especially noteworthy to point out that over a quarter of the total effort was connected with manned space flight. This very large effort is not only supporting in a very intense way the MERCURY project which is going on today, but it is looking into the future to the more sophisticated manned flights on which I shall have more to say later.

Mr. THOMAS. Do you have anything more advanced in the way of sophistication than the B–70?

Mr. ABBOTT. Yes. The B–70 I would not call manned space flight at all. That is a supersonic cruise airplane. It will cruise at about 2,000 miles per hour which is not space flight.

Mr. OSTERTAG. That would come under the 21.8 percent?

Mr. ABBOTT. Yes.

Mr. RHODES. I have trouble getting this 21.8 percent because I imagine the elements involved there are subsonic which is 3.2; hypersonic which is 5, VTOL which is 5.4 and supersonic 11.4 which adds up to 25 percent. Somebody made a mistake.

Mr. ABBOTT. Did I make a mistake?

Mr. RHODES. They left out the subsonic. Your 3.2 plus 21.8 is 25.

Mr. ABBOTT. I am sorry, there is an error. I take the responsibility for that.

Mr. RHODES. What about the hypersonic work? Do we have a name for that sort of thing?

Mr. ABBOTT. Work on hypersonic aircraft reflects primarily the work we are doing on the X–15 airplane at the moment. The speed is above mach 5. However a small amount of very exploratory research is going on to determine whether it is sensible or not to go ahead with hypersonic cruise aircraft. This is a very small effort.

USE OF AIRPLANES FOR MILITARY PURPOSES

Mr. THOMAS. You people should have as good judgment on the question of the future use of airplanes for military purposes as anyone since you are in the research and development field and have been for 40 years. What you are doing on any given day ought to be an indication of what will happen 10, 12, or 15 years in the future. You are supposed to be that far ahead of what is actually operating at any given day. It is generally thought among some people in the aviation construction business that they will be out of business in anywhere from 5 to 10 years but you are spending 25 percent of your dollars and time in research in a field that is generally thought to be on its way out.

Mr. ABBOTT. I would like to say about that, Mr. Thomas, that you will recall just a little while ago 100 percent of this effort was on this type of thing, so this does represent a very large reduction of effort on manned aircraft which I think is consistent with the decreasing importance and emphasis that is being given to manned aircraft. However, far from being on its way out, I think we have a paradox here in that at the very moment when attention is being attracted to missiles and space activities, aeronautics itself is on the threshold of new things which give promise of far greater advances than we have ever seen previously.

For instance, take the supersonic cruise aeroplane. Present day aeroplanes cruise subsonically, if they cruise any distance at all. Certain craft, such as the B–58, have the capability of supersonic dash for short distances. We now see the distinct technical possibility, in fact the probability, of aeroplanes which will be large and economical and which will be capable of cruising at 2,000 miles an hour, or even faster, for very long distances, with economy which would be quite comparable to that being achieved today in our commercial jet transports which cruise at high subsonic speeds.

Now the military has not given up their desire for such aeroplanes as evidenced by the fact the B–70 is still being continued, although at a lower rate. The future of such aircraft for commercial transportation almost shakes one's imagination when you think of what has happened from the introduction of our present-day jets which only increased the speed by 200 or 300 miles an hour. Now we are talking about an increase in speed from 600 miles an hour to 2,000 miles an hour, or thereabouts, in one jump. At the same time, VTOL aircraft, which is at the other end of the speed scale——

Mr. THOMAS. Of course there is no unanimity of opinion among the military people, the White House and the Bureau of the Budget, but suppose there is unanimity of opinion, and suppose you get this plane up to where it will go 3,500 miles an hour at 150,000 feet. What useful purpose will that have as a military instrument against a missile?

Mr. ABBOTT. I would prefer to leave the answer of the military usefulness of such a plane to the military services.

Mr. THOMAS. They have a lot of answers. They will do a lot of tricks that a missile cannot do, but as a general proposition it looks like it is still on its way out if we are going to develop missiles.

Mr. OSTERTAG. Will the chairman yield? Right on that point—the military's efforts and development and yours—the B–70 for example is programed for research, or development to the tune of perhaps $150 million at the current level. That, as you say, is a reduction, but at least a considerable sum is being used for the development, or the research with regard to the B–70.

Now, you are associated with research in aircraft of that kind. Do you continue your research in that particular thing, or do they pick up where you leave off? After all, you both have been involved in research in an aircraft of that kind.

Mr. ABBOTT. I think I can answer that best by giving you the story on the B–70. We produced the basic research information that made the B–70 possible.

Mr. OSTERTAG. You originated it.

Mr. ABBOTT. We did not originate the project, but we did do the research that showed such a project could be originated and carried through to completion. Then the Air Force made a contract with North American Aviation to develop the airplane. Immediately this happened our type of activity changed completely from general research on this aeroplane to the specific problems which the designers were encountering in trying to translate the general research into a piece of hardware, and this is the type of work we are doing now. This is largely a matter of consultation with them, specific testing in our wind tunnels to determine whether they can do it better this way or that way, as the case may be, but all within the framework of research activity. Our activity on the B–70 at the present time is limited to that.

We are still in the area of general research relating to the supersonic transport, which would more or less fly at the same speed, but we are about approaching the end of that, too, so that unless somebody picks up the design of one of these transports, we will be phasing out of that activity.

Mr. OSTERTAG. So there is a certain amount, but a small amount of overlapping as between your research and theirs in the development of a weapon of that kind?

Mr. ABBOTT. I think it depends on what one means by overlapping. Our activities are interlaced.

Mr. OSTERTAG. We will put it that way; good.

Dr. DRYDEN. Mr. Chairman, may I say a word about manned aircraft? I don't believe that the military will ever get along without airplanes. They may not have them in the same numbers. I think, myself, that the pendulum may have swung a little bit far. We are all familiar with what happened when the Russians put up a space vehicle. I regret to say that if the Russians put up a supersonic airplane, you will see this country again scrambling to regain the lead in supersonic airplanes. I regret to see our programs determined by what somebody else does. I think we must maintain a capability and a competence in high speed aircraft. Otherwise, we are headed for a period which can be dangerous. A missile can shoot one airplane down just as one bullet from one gun can kill one soldier. Nevertheless, in a war, it is not quite as simple as that.

Mr. OSTERTAG. It was my desire to bring out the relationship between the two, so that there is a reasonable amount of coordination. I would like to raise this question on this B–70 before I leave it.

Does the B–70 today incorporate the new wing which you people developed? And if it does not, is it not obsolete?

Mr. ABBOTT. The B–70 is not obsolete.

Mr. OSTERTAG. I do not mean the B–70.

Mr. ABBOTT. I don't know specifically which wing you refer to with regard to the wing that we developed. We have worked on several possible configurations, including wing shapes, for such an airplane. Now the question as to whether one of these configurations is better than another one depends in the final analysis on all the compromises that the designer has to make. The designer is using one of these concepts and we have every reason to believe that it will be a very successful flying machine.

Mr. OSTERTAG. That is all.

Mr. THOMAS. Getting back to what Dr. Dryden said a while ago, I think he is certainly correct in his general conclusion that the airplane is here to stay; but for the transportation of a warhead, do you think the airplane is here to stay, Doctor?

Dr. DRYDEN. I think there will be many situations in which the airplane will be used for delivering warheads.

Mr. HORNER. The simple way to understand this, Mr. Chairman, is to recognize that missiles generally are instruments of total or general war, whereas aircraft are more useful in the limited war situation.

Mr. THOMAS. You have tactical missiles. They go 25, 40, or 50 miles.

Mr. HORNER. Even the tactical missiles are so deployed as to support general war and it is hard to foresee most limited war situations where you would use tactical missiles because they, too, are armed with nuclear warheads.

DISTRIBUTION OF RESEARCH EFFORT

Mr. ABBOTT. If I might go on, I have shown on this chart the planned distribution of effort at the research centers for fiscal year 1961 consistent with the budget figures which are before you. This time the distribution of effort is shown by program area, which is another way of looking at it, and they are arranged here in order of decreasing effort. The large emphasis which is shown here on hypersonic aerodynamics and flight mechanics is for the most part directly associated with space activities, particularly the reentry problem which I will have more to talk about later. The chemical rockets research, which comes next, is, I think, of obvious importance; then the emphasis on materials and structures research is also fairly obvious and has to do primarily with the high temperature problem which is associated both with rocket engines and with the aerodynamic heating during reentry from space.

The smaller activities which are shown down here generally fall—I think all fall in either one of two categories. They are either new areas in which we are just beginning to get going, such as this power generation research and the electrical rockets research, or they represent other areas in which we are phasing out, such as the jet engine research, which only 2 years ago was a very large effort, and would then have fallen up in here someplace.

Mr. THOMAS. Doctor, in your figure of 25 percent of your total effort on manned aircraft, is that not a little small? What was it during fiscal year 1959 and 1960?

Your figure of 25 percent applies to 1961 and 1962, does it not?

Mr. ABBOTT. The figure of 25 percent applied to about the December-January period this year and I do not think that it is going to change very rapidly in the future, unless some policy decision is made that we get out of aeronautical research.

Mr. THOMAS. What has it been during the last 12 months?

Mr. ABBOTT. About a year ago it was on the order of 50 percent in round numbers and the year before that it would have been two-thirds or three-quarters.

Mr. THOMAS. And right today it is about 50 percent, is it not? It is nearer 40 to 50 percent than 25 percent.

Mr. ABBOTT. On manned aircraft, no, sir. I don't think so.

Mr. THOMAS. What would you say it is as of today?

Mr. ABBOTT. It is about 25 percent.

Dr. DRYDEN. This 1-day sample was within a few percent of the average which we would find for a longer period around this particular time.

Mr. ABBOTT. The 1-day sample was made on December 15. It is consistent, within 1 or 2 percent of the results we get through our regular reporting procedures and it represents quite aptly, I believe, our current state of affairs.

As I say, how much we can decrease this in the future is going to depend on policy decisions; if we are going to continue to support aeronautics in the special areas in which only we have the capability of doing it, this figure is not going to decrease very fast.

Mr. THOMAS. Go ahead, Doctor.

Mr. ABBOTT. In opening this talk I mentioned objective research. Some of our general objectives are indicated on this vehicle spectrum chart. I would like to point out that at the research centers we do not design or develop vehicles. Our job is to do research to solve the technical problems that will be encountered in these vehicles.

We do, however, seek out and identify problem areas in which sufficient information is not available to permit good engineering approaches to be made and then through theoretical and experimental research we produce the information that is required to reduce these problem areas to the point that solutions are within the capability of the engineering community of this country. This was the nature of our activity in connection with the X–15, between about 1952 and 1957; between about 1953 and 1958 we produced the concepts that led to the DYNASOAR project, to the blunt ballistic missile nose cones for our ballistic missiles and also for Project MERCURY. The other vehicles shown on this chart represent some of the research problems on which we are now trying to identify problems and do the research that will be required for future design. These include such things as manned space stations, lunar vehicles, and space ferries.

I would like to turn now to one example of research that was conducted in the past which is being applied directly today to vehicles that are now being developed. This example, incidentally, is the same one that Dr. Silverstein mentioned yesterday morning, the research on the liquid hydrogen-oxygen rocket which has contributed to the CENTAUR rocket engine and which is also providing the basis for powering the upper stages of SATURN, as mentioned yesterday by General Ostrander.

Now, liquid hydrogen has long been recognized, since far back in the last century, as a matter of fact, as a very good high energy fuel. However, certain characteristics, such as its low density and the apparent hazards of use have tended to discourage its consideration as a practical fuel.

About a decade ago the Atomic Energy Commission had requirements for liquid oxygen which led them to sponsor research which made it possible to produce and handle liquid hydrogen in a fairly satisfactory manner. Encouraged by these Atomic Energy Commission results, the NACA in 1953 undertook research to see whether liquid hydrogen could be applied to improve the performance of rocket engines. We encountered a number of problems in this.

The liquid hydrogen-oxygen flame is, of course, a very hot, intensely burning flame. The combustion chamber and nozzle is cooled by the liquid hydrogen itself, which later is burned inside of it. In order to do this, we had to study the heat flow rates and thermal characteristics of liquid boiling and gaseous hydrogen. As a result of these studies and a considerable amount of experimental verification we arrived at mathematical procedures for designing these cooling passages so that they would cool the chamber.

Mr. THOMAS. This was an experiment carried on by Dr. Rothrock; where is he now?

Dr. GLENNAN. Here in headquarters as part of the long-range planning team handling the propulsion end of it.

Mr. ABBOTT. The very hot fast-burning hydrogen flame burned up the injector plates which were designed according to best information at the time and a great deal of research had to be done to find out how to keep these plates from being destroyed by this intense heat. As a result of this research from 1953 on, we succeeded at Lewis in operating a laboratory test chamber producing 5,000 pounds of thrust in November of 1957 and in December 1957, one of 20,000 pounds of thrust.

As a result of the success of this research, the Air Force let a contract with Pratt & Whitney for the CENTAUR engine in 1958. Because of the availability of the previous research results the contractor was able to make very rapid progress in this, leading to a flight engine in a really exceptionally short period of time, and as mentioned before, these same concepts are being applied to the upper stages of SATURN.

Now, this is an example of research which is essentially completed as far as we are concerned, although we will continue to aid in the development of these flight articles as problems are encountered and will provide consultation with the designers and developers. We will assist in every way we can, but essentially our basic research is complete.

PLUMBROOK REACTOR

Now I would like to turn to problems on which we are working now, which will be applied to the future. Inasmuch as the reactor at Plumbrook was mentioned several times yesterday, I have selected a problem or two there as examples.

This Plumbrook reactor is a research tool. It is a materials test reactor, which means that it is also very useful as a tool for work on heat transfer under these conditions, a field in which the NASA and NACA did a great deal of research. The status of the reactor is that it is essentially complete. We are now in the period of arranging for an operating permit. First hearings have been held, original inspections have been made and we expect to get this operating permit and be operational sometime early fall at the latest.

Mr. THOMAS. What did that installation cost up to date?

Mr. ABBOTT. To be accurate, I would have to put the figure in the record but everything put together, there is something in the neighborhood of about $7 million.

Mr. ULMER. About $11 million.

Mr. THOMAS. It is not in operation yet, though?

Mr. ABBOTT. No, sir.

I have taken one of General Ostrander's charts which you saw here yesterday to indicate the nature of some of the problems in which we are doing work. You will recall this nuclear rocket which was shown to you, which consists of the reactor and a great deal of tankage and other equipment to carry the liquid hydrogen. The principle of this, of course, is that the liquid hydrogen flows down through a turbine pump and is pumped through the reactor which heats it to a very high temperature and then it exits out through an exhaust nozzle. The actual flow is much more complicated than that as shown by all of these lines, but this is the essential principle.

Now, you will notice that we have here a large amount of tankage, piping, and other equipment which is operating essentially at the tem-

perature of liquid hydrogen, which is pretty cold. It is about −420° F., I believe. At these low temperatures materials change their characteristics a great deal. Many metals become brittle, for instance. This is bad enough for static structures, but in addition we have high-speed rotating parts, bearings, seals, and other things to contend with. These problems had to be solved, of course, in connection with the liquid hydrogen-oxygen rocket as well. In this case we have the additional problem that these very cold parts are subjected to intense radiation from the reactor.

Now, metals at room temperature and higher temperatures show an exceptional resistance to radiation damage, as compared with many other materials. It is thought that this resistance is due to a very large extent to a sort of self-mending or healing process in which, on a submicroscopic scale, individual atoms and molecules migrate within the crystals and the crystal boundaries to repair dislocations that are caused by the radiation. At these very low temperatures this ability of the atoms or molecules of the metal to migrate is strongly inhibited and very little, in fact, practically nothing is known about the radiation damage of metals at these very low temperatures. Consequently, one of the very first projects in this Plumbrook reactor will be a series of tests to explore this radiation damage to materials, primarily metals, which are exposed to intense radiation at temperatures similar to those encountered with liquid hydrogen. I think you can appreciate this is a very important problem which has to be investigated very soon if we are to have assurance that we can actually build these rather complicated pieces of equipment which will be required for a nuclear rocket.

Mr. THOMAS. Is the AEC not carrying on exactly those same experiments?

Mr. ABBOTT. No, sir; they are not. The AEC, of course, has responsibility for the design and development of the reactor itself. They do not have the responsibility for the design and development of the remainder of the vehicle. We are closely cooperating, in continual consultation with the AEC, about what we do and what they do to avoid overlapping of this type.

Mr. OSTERTAG. Then the atomic energy aspect of it is still in their hands. You are just associating the rest of it with the reactor aspect, is that right?

Mr. ABBOTT. This is primarily correct, yes. However, in cooperation with the AEC we do do work on materials and heat transfer which does affect the design of the reactors themselves. We do provide the AEC with some information of this type which they do not get for themselves.

Mr. THOMAS. You are going to have to build a laboratory in order to test your metals separately and above your already existing Plumbrook Institution, are you not?

Mr. ABBOTT. Of course, all the materials work will not be done at Plumbrook, but this particular job I mentioned of the radiation damage at low temperatures will be done in the Plumbrook reactor.

PROJECT ROVER

Mr. YATES. Mr. Abbott, I have here an editorial from the Evening Star, which indicates that the Bureau of the Budget had allotted

only $5 million to the AEC for Project ROVER, which is what you are talking about now, is it not?

Dr. DRYDEN. I can clear up this situation.

In the cuts made by the Budget Bureau there was a reduction in the overall amount to the AEC which did involve a cut in ROVER. An appeal was made by the AEC to the Budget Bureau and we supported this appeal by attending to the technological value of the program; as is frequently the case, AEC reprogramed additional money into ROVER, so that that situation has been corrected.

Mr. YATES. They programed another $16 million, apparently.

Dr. DRYDEN. Yes, sir.

Mr. YATES. You have $21 million allocated for this project?

Dr. DRYDEN. AEC has; we have 5½ million in our budget.

Mr. YATES. Is that adequate for this program?

Dr. DRYDEN. Yes. At the present time the major work is in the reactor development. We have developed the pump, we are developing the nozzle, and the turbine to drive the pump. Our expenditures will begin to pick up next year.

Mr. OSTERTAG. You have 5½ and they have 21?

Dr. GLENNAN. They have more than that. Actually, they are building——

Mr. YATES. How much do they have?

Dr. GLENNAN. $34 or $35 million, I think, something like that.

Mr. OSTERTAG. For this project?

Dr. DRYDEN. Yes, sir. The rest of it is in the construction side, in construction of test facilities in Nevada.

Mr. YATES. For construction of test facilities for this project, but for the development of the reactor itself there is $21 million allocated?

Dr. DRYDEN. That is right.

Mr. YATES. Isn't this supposed to be the real, the ultimate—not the ultimate weapon, but the ultimate in space technology? Isn't this what you are looking for?

Dr. DRYDEN. For the very long-range and difficult missions, the time scale of this project calls for a breadboard engine in 1964 as I remember, or maybe 1963.

Dr. GLENNAN. 1963, I think.

Dr. DRYDEN. 1963 for the breadboard engine. Then we will have the responsibility of contracting with industry to make a flight engine, based on their breadboard engine.

Mr. YATES. That really is not an answer to my question. Do I misunderstand the basic importance of this experiment?

Dr. DRYDEN. What I started to say is that it will come into use in space vehicles somewhere from 8 to 12 years from now. It is a longer range development which holds the potentiality of a tremendous increase in the payload, say, for a mission to Mars. Its value in an Earth satellite mission or a mission to the Moon is relatively small.

Mr. YATES. Why is that?

Mr. HORNER. The weight of the reactor. There is a minimum weight for this type system.

Dr. DRYDEN. We cannot build a small, light reactor. It has to be a pretty heavy thing. If we wanted to use it to put extremely large weights in an earth orbit, such as a manned laboratory it would be difficult to use unless we could solve the shielding problems.

Mr. BOLAND. Are you pressing this project?

Dr. DRYDEN. Yes.

Mr. ABBOTT. We are pressing research; yes, sir.

Mr. BOLAND. How many people do you have working on research for this particular problem in this program?

Mr. ABBOTT. As I said before, right now the Plumbrook reactor is not in operation, but we will have in 1961, on this, about 320 people all told, of whom about 107 will be research professionals during the fiscal year for which you are examining the budget.

Mr. BOLAND. This particluar problem is not of immediate concern. This is something which will not be realized in the next 2 or 3 years?

Dr. GLENNAN. It is a long range.

SATURN PROJECT

Mr. BOLAND. Why don't you put some of those people on the SATURN project and save money, on the effort of NASA, which appears to be the most urgent.

Dr. DRYDEN. There is a temptation, of course, to stop all long-range work.

Mr. BOLAND. We do not want to stop it.

Dr. DRYDEN. The ROVER engine is a longer range thing, so when you say to us cut out so many people or cut out money, the temptation is to do the things that we are lined up to do in the next few years and to slow up the things that we cannot realize for 5 or 6 or 7 years.

Mr. BOLAND. Why can't we slow up? What is the difference if we do slow it up for the next few years?

Dr. GLENNAN. Mr. Boland, we are jumping from $70 million this year, expended on SATURN, to $230 million next year, and the manpower assigned to that is apt to be upped by 50 percent.

Mr. HORNER. One hundred percent over last year.

Mr. BOLAND. This is all the money and manpower you can use on the SATURN project for fiscal year 1961? This is all you will need and you do not need a dime more or another body? You won't move any faster if we give you more money or more people?

Mr. OSTERTAG. Would it not be difficult to get more people?

Dr. GLENNAN. Let me answer this question first because anybody who sits here and says, "I cannot use one more man or one more dollar," is not being very realistic. On the other hand, there is a pace at which these things can grow and there is a period of time which cannot be shortened overly much.

We have cut 1 year, give or take a month, off the SATURN schedule, with the $113 million acceleration we are putting into it at the present time.

Dr. von Braun will tell you tomorrow, in his own words, whether or not this is adequate. In my opinion it is. I would not think that we would gain another 2 months if we added another $200 million to that project this year. I think this is a reasonably accurate statement.

BUREAU OF THE BUDGET REQUEST

Mr. YATES. How much money did you ask the Bureau of the Budget for?

Dr. GLENNAN. For what?

Mr. YATES. How much money did you ask the Bureau of the Budget for?

Dr. GLENNAN. For SATURN?

Mr. YATES. For the whole program.

Dr. GLENNAN. Our original request to the Bureau of the Budget totaled $783.3 million. The Bureau of the Budget allowance was $802 million which included $140 million funding for the SATURN project and $36 million for other work at the Huntsville facility. These latter two amounts, originally included in the Department of Defense budget estimates, were not part of the original NASA $783.3 million request.

Subsequently, the President approved a $113 million amendment to the 1961 budget for acceleration of the large booster program in response to our request for $125 million.

Mr. YATES. They allotted you?

Dr. GLENNAN. $915 million.

Mr. YATES. Where was the cut?

Dr. GLENNAN. It was in a number of areas, Mr. Yates.

Mr. HORNER. Construction probably was one of the major areas cut back.

Mr. YATES. Construction of facilities?

Mr. HORNER. Construction of facilities.

Mr. YATES. Will those slow up major programs?

Mr. HORNER. As Dr. Dryden mentioned, when we have to take cuts, most of the cuts are taken in the long-range research facilities; the research facilities that Mr. Abbott talks about here are the distilled products of this budgeting process and they are what we feel to be absolutely the most necessary research facilities to carry on.

Mr. YATES. Is this a minimum program you are presenting to this committee?

Mr. HORNER. I do not know that it is a minimum program.

Mr. YATES. You say this is the distilled effort. Presumably you distill it to a point where you come up with the pure essence. This sort of an explanation connotes to me a minimum program.

Mr. HORNER. We feel it is the minimum program as far as supporting research facilities is concerned, that is true.

Mr. YATES. Should you be doing more?

Mr. HORNER. In many respects we would like to be doing more. We face the fact that we are managing this program in company with a lot of other Government programs that also demand resources, as Dr. Glennan mentioned. We did not get all of the resources that we requested from the Bureau of the Budget.

Mr. YATES. I would like to know what was cut out by the Bureau of the Budget. I do not like to interrupt Mr. Abbot's statement, but I would like somebody to testify as to that later, if they will, Mr. Chairman; you could have somebody testify as to the essentiality of the programs eliminated by the Bureau of the Budget.

Mr. OSTERTAG. How does the budget compare with the authorization?

Dr. GLENNAN. It is identical.

Mr. THOMAS. They crossed all the t's and dotted all the i's.

Mr. BOLAND. That committee did?

Mr. THOMAS. Yes.

Mr. OSTERTAG. You mean the $915 million budget request before us is identical with the authorization?

Dr. GLENNAN. Exactly, sir.

Mr. OSTERTAG. In other words, the Bureau of the Budget could not give you more money, could they?

Dr. GLENNAN. The amounts approved by the Bureau of the Budget in the authorization bill are identical with the amounts approved for the appropriation bill. If the Congress votes us more money they might impound it, but I doubt they would.

Mr. OSTERTAG. What I am getting at is this: You have to have authorization before you can have money.

Dr. GLENNAN. The legislative committee did not exceed the amount which was requested.

Mr. YATES. Did you only request the amount that the committee granted to you?

Dr. GLENNAN. We requested $915 million and that is what they granted.

Mr. YATES. Did the committee ask you how much money you had requested from the Bureau of the Budget?

Dr. GLENNAN. Yes, sir.

Mr. YATES. They came up with this amount?

Dr. GLENNAN. Yes.

I think, Mr. Yates, one ought to say that here, again, we are driving a program forward with urgency along a rather broad front. It is our considered opinion that we have a well-rounded program. By that, I do not mean anything that is static.

One could always do very much more with very much more money. If we were to get more money today, I would, I think, insist that the first use of that money be in support of these projects we are giving to you today in the sense that we would perform more ground tests, we would attempt more thorough development of component parts, more advanced development, but we would not, in the first instance, lay on a lot of additional programs.

We would seek to gain greater assurance that when we reached that point in time when we wanted to make a firing, we had a good chance for success.

Mr. YATES. Mr. Chairman, with your permission, may I read a quote from the magazine Air Force and Space Digest for March 1960, which is an extract from the first interim report on Project Mercury prepared by the Staff of the House Committee on Science and Astronautics.

Admittedly, this is your No. 1 project, is it not, Project MERCURY?

Dr. GLENNAN. Yes, sir.

Mr. YATES. That is what the quote says:

At the present time Project MERCURY is our only program funded and actually underway for putting man into orbit. Considering the number of challenging new techniques which must be mastered to make a space flight a success, there

is question whether the national interest is best served by the single approach to this problem. The only provision against the hazards of all eggs in one basket has been to have backup contracts on those components for MERCURY which are most likely to provide trouble. There are a number of very promising alternative approaches to putting men in space. By setting a limit on testing these concepts through exclusive adoption of the MERCURY approach, the Nation is risking the loss of extremely valuable development time.

The country cannot support a large number of approaches in competition with all the other demands on fiscal and personal resources, but at the same time, the failure to develop in parallel, at least one other man-in-space program, could prove to be a costly mistake.

Is this a valid criticism?

Dr. DRYDEN. That approach would require another 300 million for a second manned space project, and unless there is a very different scale of national effort to be put into space, I do not think that is a wise thing to do.

Mr. YATES. You have two approaches to the project now rather than one?

Dr. DRYDEN. As the article explained, and if you read the House committee report in detail, there are backups to all components in this project which are likely to give problems. There is not an independent project as you had in THOR and JUPITER and in ATLAS and TITAN. To do that would require an additional sum of the order of $300 million. Certainly unless the order of magnitude of the moneys that you put into space is increased very substantially, you would not do this.

Mr. THOMAS. That was very well explained yesterday, I thought, in very simple language, picturesque language, even though it was simple. Either you or Dr. Glennan explained the difference between a rush program and a crash program. In a crash program you attempt to do the same thing by perhaps three different systems, and then you check out which is the best of the three systems.

A good rush program, which you are undertaking here, is picking out one probably good system and rushing it to completion. The charts have shown innumerable times some 12 or 15 different rockets that are your interim rockets, waiting until you get your big one.

Dr. GLENNAN. The difficulty with the crash program, as you well know, Mr. Thomas, is that you never have the courage, or you are never allowed by the pressures external to your organization, to cut out one of these when you get to the point you find it is not just going to be the best.

Mr. BOLAND. You are going to reach your objective with the project you have. You are convinced you are going to do this. That is all you want to do, is it not?

Dr. GLENNAN. Yes, sir.

Mr. THOMAS. If you had three programs, you would not complete any one of them any quicker than you are going to complete this one.

Dr. DRYDEN. It might take longer by the required splitting up of your effort.

Dr. GLENNAN. There is a finite capability in manpower in this country and if you channel all of it into one of these programs you have to give up something else. It is tremendously important, I think, that we use the manpower we have sensibly and effectively.

We talk about dollars. These are the easiest things to talk about, but you are really talking about good manpower when you talk about

dollars. There is a limit to how much you can put on any one project.

Mr. THOMAS. There are 16,000 personnel plus another 2,400 at JPL. We have the Air Force, plus the AEC. I think the doctor very well expressed it. There is a limit to your manpower.

Dr. DRYDEN. The $600 million in the R. & D. program means men, too, in industry, and elsewhere. A large amount of it goes for manpower in industry.

There is another point about this budget that I would like to bring out at some time. Some of us who had the old experience, Mr. Thomas, in NACA, are becoming acquainted with the cost overruns because of new things developing during the course of the project and as you know, there is no contingency fund anywhere.

There is no emergency fund in NASA such as the Secretary of Defense has, so that the only recourse we have when we do run into additional costs is to reprogram for the time being and then come back and ask you for more money, as we have done for the last 2 years.

This time, fortunately, it was only about $23 million, but this is a new experience for some of us who have been accustomed to another method; as you expressed it the other day, if we got less money than we had asked for to build a facility we cut our cloth to fit. We have not mastered the art of doing this in a project like MERCURY, where we are trying to rush, where we must go ahead and design a capsule and then find that the fellows who are going to fly in it have valid objections to where the window is, or what the arrangement of instruments is and we have to make engineering changes. This process is a very familiar one in the Department of Defense operation.

These are the kinds of things that are new to us and there is no slack.

Mr. THOMAS. It is new to everybody, Doctor.

You are not by yourself.

Dr. DRYDEN. I was just pointing out, there is no slack in these numbers. If we run into additional costs on important projects, the only recourse, if the amount is small enough, is to do reprograming as the AEC did in the case of ROVER, or to come back to Congress and ask for more funds.

Mr. THOMAS. Go ahead, Mr. Abbott.

Mr. ABBOTT. Yes, sir.

MATERIALS AND STRUCTURES RESEARCH

I would like to mention some of our materials work for a moment, since this was mentioned by you a few moments ago, and also mention that we do some work on material which relates to reactors.

Mr. THOMAS. Off the record.

(Discussion off the record.)

Mr. ABBOTT. I thought it was appropriate to bring it up again.

Mr. THOMAS. Very appropriate; go ahead.

Mr. ABBOTT. There were some questions about the weight.

Mr. THOMAS. Is it still awfully heavy?

Mr. ABBOTT. It is awfully heavy. There was some question about the weights of these reactors. They are quite heavy and require very large vehicles to carry them.

One of the very fruitful lines of research, of course, would be anything that could be done to make them lighter. This would cut down the ultimate cost of the vehicles a great deal.

Theoretical work indicates that the reactor could be made more efficient and considerably lighter and use considerably less nuclear fuel, which is very expensive, if one of the tungsten isotopes could be used. Tungsten is very attractive in some respects. It has a very high melting temperature of around 6,000° and is probably useful up to nearly 5,500°.

However, it is heavy, as you know, and this means that it has to be used very efficiently. We also have other problems. It is very brittle. Useful structural material has to be capable of being bent and tungsten is not.

I have here some samples of tungsten. You can see what happens if I try to bend it. If anybody else wants to break one, here is another one.

This is high-grade tungsten, the best that is commercially available. That is the kind of characteristics it has, which makes it pretty useless for the purpose.

At Lewis we have been working rather intensively on this. Here is an example of a piece of tungsten which we treated at Lewis which has been bent into a shape like this, which I think represents some very real progress in handling tungsten. However, we are not done. This has been bent once, but now it is brittle again so we still have a long way to go, but I think we are making progress.

Mr. OSTERTAG. You mean time changes it?

Mr. ABBOTT. No, just the fact of bending it makes it brittle again. This happens to a very large extent even on copper, as you know.

The potential gains from this sort of thing are very large. I am not talking about 10- or 15-percent gains. Theory indicates that if tungsten could be properly used the weight of the reactor might be reduced to about one-half and the amount of nuclear fuel that would be required for the same power would be reduced to the order of a quarter to a third as compared with the present reactors so the potentialities of this sort of work are very great as far as the future is concerned.

I would like to turn briefly now to another problem.

Mr. RHODES. Mr. Chairman, before Mr. Abbott leaves that subject, what temperature do you develop in a reactor?

(Discussion off the record.)

Mr. RHODES. Does the liquid hydrogen actually undergo a process of combustion in that reactor or is it just an expansion of the element itself?

Mr. ABBOTT. It is just heated.

Mr. RHODES. Heated so it expands?

Mr. ABBOTT. Yes. In the case of the hydrogen leaving the nozzle and flowing out into the atmosphere while it is in the atmosphere, it will burn at that point, but in the reactor, it is just heated. What you want is a good jet, an efficient jet with very hot gas with very low atomic weight. This gives a very hot gas and the very low atomic weight of hydrogen. If it were burned, the atomic weight would go up.

The lunar mission has been mentioned here several times. There are many research problems connected with it. This lunar mission has

various phases: There is the launch and exit phase, space flight phase, lunar orbit phase, in which exploration of the moon would be made by landing instruments, and by observation; eventually landing of man on the moon, return to earth, and the reentry into the atmosphere and landing. There are many research problems which have to be solved before we can do any of these things. We are busy working on all of them, but to be concise here I will talk only about a few of the problems in connection with the launch and exit, and reentry.

Let us consider the launch and exit problem.

I have shown here schematically the type of vehicle that would be used. It is basically a SATURN, with appropriate upper stages and an appropriate vehicle on top. A launch vehicle like this is very large and heavy. It might be of the order of 300 feet long, weigh probably about a million pounds. It is balanced on these rockets, giving a thrust of 1.5 million pounds.

Because weight is so important in such a vehicle, the structure of this vehicle will be very light and flimsy by normal standards.

Now, we need to know how to design these structures better. There are research problems in connection with that. This vehicle, in going up through the dense turbulent atmosphere, is subject to side loads from wind shears and turbulence in the atmosphere. It also receives side loads from the sidewise component of thrust in these gimbaled engines.

These loads are not steady. Consequently, we call them dynamic loads. They set up vibrations in the structure which interfere with the sensors of the guidance and control system which maintains the proper orientation. This creates a very complicated problem of dynamic loads and vibration and guidance control which needs a great deal more research.

We also have a base heating problem here, to prevent the destruction of the structure near the rear end of the vehicle by the burning exhaust gases. This has proved to be a very troublesome problem on these vehicles and requires a series of very large wind tunnel tests to work out this problem.

We are working on all these problems and on several more, such as the fuel-sloshing problem, in connection with such vehicles and more particularly at this time in direct support of the SATURN development program.

REENTRY RESEARCH

Going now to the reentry from the moon, again, we have many research problems. This reentry can be accomplished in several ways. However, we could use a ballistic vehicle which would be a direct extrapolation of our MERCURY experience, and we would then be coming in with something that looks vaguely like the Mercury capsule.

It is important to remember that the velocity of this vehicle is higher than the velocity of satellite reentry in the Mercury project. Perhaps, you can imagine this vehicle coming in from a point a quarter of a million miles away at 27,000 miles per hour. Calculations show that if it is to enter the atmosphere and come to a landing on its first circuit around the earth, it must come in on a trajectory within, plus or minus, 3½ miles. The total width of the trajectory corridor is only 7 miles. If the capsule undershoots the trajectory, the occupants will be destroyed by the high deceleration

in the atmosphere. If it overshoots, it will go on back into space for another excursion through the radiation belts, with the probability of several additional days of flight, if it is possible to bring it back to the earth at all.

This 7 miles is a very small target to hit. It is actually less than one one-thousandth the diameter of the earth. On the chart the width has been exaggerated 10 times in order that you can see it.

There is no present guidance system which is capable of doing the job consistently in a practical way for a manned vehicle.

We are working on this guidance problem, but we are not just leaving it at that researchwise.

There are other ways of improving the guidance problem, and one of them is to use a lifting vehicle such as a vehicle with some elementary wings on it. By such means, this corridor can be increased in width to as much as 120 miles, or even more. This greatly reduces the guidance and control problem and reduces the deceleration problem. It does not reduce but augments the severe problems of aerodynamic heating and resulting materials and structural problems. It does this to such an exent that such a vehicle would be quite heavy. We simply do not know today how to design such a vehicle. Again, we are doing research on the problems, but it appears that a practical solution is a long way in the future.

Fortunately, I have represented only two extremes. The more sensible approach to the problem is to use a vehicle which provides some lift but does it without wings as shown here. With such a body it is possible to widen this corridor to something like 40 miles, let us say, which considerably reduces the guidance and trajectory control problem and also reduces the deceleration problem. The aerodynamics heating and materials and structural problems are much more severe than they are for MERCURY, but we are doing a great deal of research on them and it does appear that, for this type of vehicle, solutions will become available in the near future.

There remains a very serious stability and control problem, because this vehicle has to be kept properly oriented and controlled in the atmosphere either by fully automatic means or by the pilot or by some combination of the two. Again, very intensive research on this problem is going on at the moment. It is problems such as these which account for the very heavy efforts which are shown in some areas of activity on the previous charts.

Finally, I have a summary of the budget request to support our advanced research programs.

The S. & E. request for the research centers is shown here. We are requesting $73.9 million this year for the four research centers.

The R. & D. support for plant at the research centers is $23.4 million. The increase here is directly associated with the greatly increased cost of conducting research in the new technology that I have been describing.

The research grants and contracts which enable us to take advantage of the very outstanding talents which exist throughout the country at the universities and other research organizations is next at $10 million. Finally, the construction and equipment request of just over $22 million, which represents about 5 percent of the original construction cost of the four research centers.

Mr. THOMAS. That was a very nice presentation, Mr. Abbott. Thank you very much.

Mr. ABBOTT. Thank you, sir.

Mr. THOMAS. Gentlemen, let us get some lunch and see if we can get back here at about 12:30 and then we will go into the budget and see if we can wind it up sometime tomorrow.

AFTERNOON SESSION

Mr. THOMAS. Gentlemen, the committee will please come to order.

We had wound up all of our statements. I think they were excellent. It was a fine summary of each program.

BOOSTER SYSTEMS

Mr. Yates, did you have some general questions?

Mr. YATES. Yes.

First of all, I would like to ask Dr. Silverstein about a couple of statements in last year's hearing which I had read, which seemed to disturb me a little bit in retrospect. I wondered whether the same situation prevailed today. On page 22 of last year's hearing the doctor said:

> We have been currently working with booster systems that were derived from the military missile program. We have been using THORS and ATLASES with upper stages that were not designed to match the missiles because we were in such a hurry to get satellites, probes aloft, we did not take time to go through the long development leadtime required to create new booster systems.
>
> One of our first acts when this organization was formed in October was to recognize this weakness in our program. It was a grave weakness. We met with the Defense Department recognizing the joint needs of the committee—

et cetera. Are you still using mismatched systems?

Dr. SILVERSTEIN. Yes, sir.

Mr. YATES. Does this prevent your program from operating efficiently?

Dr. SILVERSTEIN. Well, it does this: Optimum use of the ATLAS with an upper stage such as AGENA or CENTAUR will enable you to put up from—into, say, the satellite mission, some 5,000 to 8,000 pounds, whereas the ATLAS, mated with the VANGUARD upper stages as we do in the ATLAS-ABLE cuts this to almost a third. So you see this is the mismating I was discussing and we are going ahead for example with the ATLAS-ABLE lunar shots this year because we have no other behicles available.

Mr. YATES. You stated then again on page 24:

> What happens is we get a very low efficiency or very low return for the money invested. We might have 1 pound of payload for a thousand pounds of missile weight whereas with the later missile systems we are creating we can increase this factor by 10.

Does this situation still prevail?

Dr. SILVERSTEIN. That still prevails.

Mr. YATES. When will you move out of it?

Dr. SILVERSTEIN. We will move out first with the ATLAS-AGENA system coming into use followed with the ATLAS-CENTAUR system coming in the middle of 1961, and of course, our SATURN systems are well matched.

MILITARY SIGNIFICANCE OF SPACE

Mr. YATES. The next question I want to address myself to is the question of whether space has military significance. I asked a question of someone yesterday. I thought it might have been Dr. Glennan.

I commented on the statement that the President had made, namely, that he sought to draw the line between civilian space activity and military activity.

Is there a distinction? I read from an article in the Sunday Star of March 13 from an interview with General White in which he, in answer to a question, says, "There is no question in my mind that outer space has a military significance."

Aren't your experiments essential for military purposes as well as for the civilian experiments that you have?

Dr. DRYDEN. There are essential in the sense that both are based on the same technology.

Again, you might compare it with the situation in airplanes. The principal differences between civil and military aircraft are first, in the equipment carried, and second, in performance. Now, the performance element has not yet entered into military space activities. In other words, both the military equipment and the civilian equipment is carried in vehicles, satellite vehicles of about the same performance capabilities.

For the present the military missions involve satellites only. We have not yet found or even thought of any military mission of the type that PIONEER V is now carrying out. That is purely a civilian space mission.

At the present time the military applications which are being worked on very hard are reconnaissance and early warning satellites, and communications satellites systems.

There is even, within the military, argument and discussion about the military value of satellite communication systems based on the early state of the art. A satellite follows a perfectly predictable course. You can observe its orbit, know where it is going to be tomorrow or an hour from now, which would seem to make the task of bringing it down fairly easy. Many people think that the early systems are much more suitable for civilian communications, where you do not believe that anybody is going to deliberately undertake to bring a civilian communication satellite down. This is a matter which may be solved by increasing the complexity of the military satellite, giving it some power to change its orbit—this would require additional fuel. I think the trend will move in this direction, toward the use of and need for heavier satellites for military application.

Mr. YATES. Dr. Dryden, I read from a magazine entitled "Air Force and Space Digest," for March, 1960. There is an editorial entitled "Peace on Earth Controlled From Space." I do not know whether you read this.

Dr. DRYDEN. I do not recall this particular one. The truth at the moment is that fellows who control the ground are the fellows who control space rather than the other way around.

Mr. YATES. They speak of being able to prevent surprise attacks.

Dr. DRYDEN. This is with the early warning satellite.

Mr. YATES. Are you working on this?

Dr. DRYDEN. No; the military has a very active program on this.
Mr. YATES. You have nothing to do with this?
Dr. DRYDEN. We have nothing directly to do with that, no.
Mr. YATES. What laboratories would be working on this?
Dr. DRYDEN. This is being done by Lockheed.
Mr. HORNER. There are many contractors working on the program.

RUSSIAN PROGRESS

Mr. YATES. One final question: Yesterday I asked you about the rate of Russian progress and you indicated that one of the reasons they were ahead in the rocket engine was because they had begun to work on this 4 years before we did. Do I interpret your answer correctly?

Dr. DRYDEN. They organized to do a space job 4 years before we did.

Mr. YATES. When did they start?

Dr. DRYDEN. In 1954 the Soviet Government set up the Interplanetary Communications Commission, with Professor Sedov as the chairman. This is the group that has been carrying on the scientific part of their satellite work. Some of the members of that commission are not only scientists and active in their Academy of Sciences but they also wear uniforms at times and hold commissions in the Soviet military service. They sort of double in brass.

The Russians had had an early start in space somewhat by accident: the accident that their atomic bombs were very much heavier than those that were developed in this country, very early. This was also true of the H-bomb development. As a result of that, the Russians required a rocket for their intercontinental ballistic missile of larger thrust than did the United States. It is believed to be in the range of 600,000 or 800,000 pounds thrust where, as you know, we get along with about 350,000 pounds thrust.

This more or less accidental nature of their less efficient development, if you like, put them at a great advantage in space because it takes about 4 or 5 years to develop a booster of this size.

This gave them this 4-year head start in the space business.

Mr. YATES. When did we start?

Dr. DRYDEN. The corresponding step taken by our Government was the creation of this Agency, NASA, in October of 1958. The Space Act was passed actually, of course, in the summer of 1958. In both countries there was some private activity, private interest which antedated the official formation of the Government body.

Mr. YATES. Did we know about the creation by the Russians of their space agency in 1954?

Dr. DRYDEN. It was fairly well advertised. You will recall that the general attitude in our country was that this was far into the future.

Mr. JONAS. May I ask Dr. Dryden a question there?

Mr. THOMAS. Mr. Jonas.

Mr. JONAS. Did you say there was some activity among private interests in both countries before Russia announced organization of the committee?

Dr. DRYDEN. Yes.

I believe in this country the first recorded agitation for a satellite was the report from the Rand Corp. to the Air Force, about 1946, if I am not mistaken, in which they recommended to the Air Force that a project of this kind be undertaken.

Mr. JONAS. I can understand private activity in this country. I did not know that situation existed in Russia though, or a comparable one.

Dr. DRYDEN. One of the rocket pioneers that we sort of group along with Goddard in this country is a man by the name of Tsiolkovsky. In this country our first talk of space activities, at least one of the first landmarks, was the experimental work of Goddard, who made rockets with the same fuel combinations that we use today.

Mr. JONAS. I understand. What is the comparable private activity?

Dr. DRYDEN. Tsiolkovsky was a Russian scientist interested in rockets and their application in space. In Germany a scientist by the name of Oberth was one of the early ones who had papers printed giving ideas about space flight. Scientists and engineers took these as speculative imagination of people rather than as a project in which sound citizens would invest money and undertake activities.

Mr. JONAS. The Russian to whom you refer was not a private citizen in the same way we understand private citizens operate. He worked for the Government, did he not?

Dr. DRYDEN. He was a member of the academy. He was not a governmental employee at that time. This was in times of czarist Russia, a long while ago.

Mr. THOMAS. Gentlemen, let us take a look at the budget now, dollarwise. We have had good indoctrination in theory. Let us look at it from the financial side.

SUMMARY OF APPROPRIATIONS

Mr. Reporter, put the cover sheet of page 1 in here. It gives you a breakdown between salaries and expenses, research and development and construction for fiscal year 1961: "Salaries and expenses," $170,760,000; "Research and development," $621,453,000; "Construction and equipment," $122,787,000; making a grand total of $915 million.

(The page referred to is as follows:)

Appropriation summary

	Salaries and expenses	Research and development	Construction and equipment	Total
Approved, fiscal year 1959:				
Independent Offices Appropriation Act, 1959 (Public Law 85-844)	$78,100,000		$23,000,000	$101,100,000
Supplemental Appropriation Act, 1959 (Public Law 85-766)	5,000,000	$50,000,000	25,000,000	80,000,000
Second Supplemental Appropriation Act, 1959 (Public Law 86-30)	3,186,300			3,186,300
Transfers from DOD (72 Stat. 433)		154,619,532		154,619,532
Total	86,286,300	204,619,532	48,000,000	338,905,832
Approved, fiscal year 1960:				
Supplemental Appropriation Act, 1960 (Public Law 86-213)	91,400,000	335,350,000	73,825,000	500,575,000
Appropriation transfer (Public Law 86-213)		−15,000,000	15,000,000	
Total	91,400,000	320,350,000	88,825,000	500,575,000
Requested, fiscal year 1960: Supplemental estimates		12,200,000	10,800,000	23,000,000
Requested, fiscal year 1961: Regular estimates	170,760,000	621,453,000	122,787,000	915,000,000

Salaries and Expenses

Program and financing

	1959 actual	1960 estimate	1961 estimate
Program by activities:			
1. Aeronautical and space research	$77,147,637	$74,000,000	$73,940,000
2. Space flight development and operations	8,814,289	30,000,000	86,420,000
3. Program direction	5,069,915	8,000,000	10,400,000
Total program costs	91,031,841	112,000,000	170,760,000
4. Relation of costs to obligations: Costs financed from obligations of other years, net (−)	−1,055,326	−5,600,000	
Total program (obligations)	89,976,515	106,400,000	170,760,000
Financing:			
Comparative transfer from (−) Department of Defense	−5,000,000	−15,000,000	
1959 appropriation available in 1958	1,011,781		
Unobligated balance no longer available	298,004		
Appropriation (new obligational authority)	86,286,300	91,400,000	170,760,000

Object classification

		1959 actual	1960 estimate	1961 estimate
	Total number of permanent positions	8,930	10,086	16,373
	Full-time equivalent of all other positions		8	30
	Average number of all employees	8,326	9,693	16,130
	Number of employees at end of year	8,879	10,031	16,327
	Average GS grade and salary	9.0 $7,399	9.3 $7,585	9.6 $7,838
	Average salary for grades established by the Administrator of the NASA	$5,995	$6,264	$6,213
01	Personal services:			
	Permanent positions	$57,831,267	$69,926,440	$117,857,000
	Positions other than permanent	2,329	67,900	250,000
	Other personal services	911,524	2,286,460	10,518,000
	Total personal services	58,745,120	72,280,800	128,625,000
02	Travel	1,097,218	2,866,400	5,849,000
03	Transportation of things	374,696	191,000	442,000
04	Communication services	451,869	883,600	1,314,000
05	Rents and utility services:			
	Electric power	6,191,226	6,494,800	7,843,000
	Other utilities	398,367	469,000	600,000
	Rentals	1,541,553	2,585,000	15,399,000
06	Printing and reproduction	160,466	203,000	363,000
07	Other contractual services:			
	Research contracts	816,510		
	Repairs and alterations	1,091,832		
	Miscellaneous services	935,780	214,000	1,292,500
	Services performed by other agencies:			
	Research services	148,367		
	Security investigations	178,595	500,000	1,248,000
	Other services	5,206,718	15,000,000	
08	Supplies and materials	6,513,992		
09	Equipment	3,402,407		
11	Grants, subsidies, and contributions	3,719,808	4,566,300	7,618,500
13	Refunds, awards, and indemnities	3,202	134,000	147,000
15	Taxes and assessments	10,570	12,100	19,000
1959	Program obligated in 1958	−1,011,781		
	Total obligations	89,976,515	106,400,000	170,760,000

Mr. THOMAS. Let us take a look at salaries.

I might say for the Budget people, you have certainly come up with a world of information. It is most conveniently gotten up. The omissions are not too many. I could point out one or two, but it is an excellent job.

Mr. ULMER. Thank you, sir.

JUSTIFICATION OF THE ESTIMATE

Mr. THOMAS. Let us put pages 4 and 5 in the record.

(The pages referred to follow:)

PROGRAM AND PERFORMANCE

This appropriation provides for the salaries and operating expenses (other than supplies, equipment, and construction) of the research and development centers and other activities operated by the National Aeronautics and Space Administration with Government personnel.

1. *Aeronautical and space research.*—Research is conducted at the Langley, Ames, and Lewis Flight Research Centers, located at Langley Air Force Base, Va.; Sunnyvale, Calif.; Cleveland, Ohio; and Edwards Air Force Base, Calif., respectively. The level of operations at these centers will be substantially the same in 1961 as in 1960.

2. *Space flight development and operations.*—The Goddard Space Flight Center at Beltsville, Md., will be the data center for NASA space operations; it will also be responsible for payloads, primarily for earth satellites, and for directing the manned space flight program. The Wallops Station in Virginia will be utilized

for launching sounding rockets, test vehicles, and small satellites. The NASA facility at Huntsville, Ala., will engage in space vehicle development including the SATURN very high thrust booster project. NASA personnel are also located at the Atlantic and Pacific Missile Ranges and worldwide tracking stations. The large increase in 1961 results primarily from the inclusion for the first time in this appropriation of the full amount of salaries and expenses for the Huntsville facility which is being transferred to NASA from the Army. This facility was supported previously by funds for specific missile and space projects, chiefly of the Department of Defense, through the mechanism of work orders placed with the Army industrial fund at the Army Ballistic Missiles Agency. Other increases are required in 1961 for the Goddard Space Flight Center and Wallops Station because of increased workload.

3. *Program direction.*—Increased funding for personnel is required at the NASA headquarters as the size and complexity of the programs continue to grow.

4. *Relation of costs to obligations.*—The relationship is derived from yearend balances of selected resources and applicable adjustment as reflected in the following table:

	1958 actual	1959 actual	1960 estimate	1961 estimate
Selected resources at end of year:				
Inventories and items on order:				
Unpaid undelivered orders (appropriation balances obligated for goods and services on order not yet received)	$5,472,781	$4,215,268	$215,268	$315,268
Advances (payments for goods and services on order not yet received)	94,869	93,369	3,369	3,369
Accrued annual leave (leave earned and not taken by employees, charged to activity costs)	−4,677,125	−5,552,948	6,262,948	−6,562,948
Unapplied costs (costs incurred not yet assigned to activities)	382,480	1,323,876	523,876	723,876
Total selected resources at end of year	1,273,005	79,565	−5,520,435	−5,520,435
Selected resources at start of year		−1,273,005	−79,565	5,520,435
Adjustment of selected resources reported at start of year		138,114		
Costs financed from obligations of other years, net (−)		−1,055,326	−5,600,000	

Mr. THOMAS. May I read from page 4?

Research is conducted at the Langley, Ames, Lewis, and flight research centers, located at Langley Air Force Base, Va.; Sunnyvale, Calif.; Cleveland, Ohio, and Edwards Air Force Base, Calif., respectively. The level of operations at these centers will be substantially the same in 1961 as in 1960.

Following this are some very excellent tables. We will put them in the record at the proper time.

I pointed out yesterday that I do not find a breakdown on the California laboratory. Did I overlook it?

Mr. ULMER. You did not overlook it, Mr. Thomas. That is one of the omissions you mentioned.

Mr. THOMAS. Can we have one I can use?

Mr. ULMER. It is being prepared and should be ready by tomorrow, I believe.

Mr. THOMAS. Pages 7–1 and 7–2 have some very excellent reading. I suggested to you, it adds up that you want 16,373 personnel for this year.

The nucleus was provided by the 8,040 staff members of the laboratories and the headquarters of the NACA.

To this were added 400 members of the VANGUARD team, transferred from the Naval Research Laboratory. Seven hundred new positions were provided in the first fiscal year, and an additional 700 in the current fiscal year to round out the staff and to provide the technical and scientific skills that were not

present in the older laboratories but are required for the new business of space exploration.

That bring you up to the 16,373 figure of directly appropriated personnel plus the 2,400 in California?

Mr. ULMER. Yes.

Mr. THOMAS. It makes a total of how many?

Mr. ULMER. About 18,000 or 19,000.

Mr. THOMAS. 18,773.

Mr. HORNER. I think it points out later that there are actually 2,700 at JPL at the present time. It will be reduced to 2,400 as the Army work in JPL phases out.

SUMMARY OF EXPENSES

Mr. THOMAS. Let us take a look at the tables. They are quite informative. Put the table on page 8 in here. It gives you personal services of $128,625,000 against $72 million last year and the difference between $170,760,000 and your $128 million is for your other objects.

(The page referred to follows:)

Object	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
01 Personal services	$58,745,120	$72,280,800	$128,625,000
02 Travel	1,067,218	2,866,400	5,849,000
03 Transportation of things	374,696	191,000	442,000
04 Communication services	451,869	883,600	1,314,000
05 Rents and utility services	8,131,146	9,548,800	23,842,000
06 Printing and reproduction	160,466	203,000	363 000
07 Other contractual services	3,377,802	714,000	2,540,500
08 Supplies and materials	6,513,992		
09 Equipment	3,402,407		
11 Grants, subsidies, and contributions	3,719,808	4,566,300	7,618,500
13 Refunds, awards, and indemnities	3,202	134,000	147,000
15 Taxes and assessments	10,570	12,100	19,000
Total	85,988,296	91,400,000	170,760,000
Unobligated balance	298,004		
Total appropriations	86,286,300	91,400,000	170,760,000

NONSALARY EXPENSES

In other words, your other objects are running quite heavy, about $48 or $49 million.

Dr. DRYDEN. Half of which is involved in the rents and utilities services.

RENTS AND UTILITIES

Mr. THOMAS. Your travel goes from $2,866,400 to $5,849,000, a little better than 100 percent. Your rents and utilities are your big item; in fact, they are second. It goes from $9½ million up to $23,842,000. Of course, the biggest item in there is your electric power. You set that out and I chased all over the place looking for your Huntsville power bill. What is it?

Mr. ULMER. Huntsville power, sir, is purchased on a reimbursable contract to the AOMC; the power bill will be about $518,000 next year.

Dr. DRYDEN. It is comparatively minor because there are no big wind tunnel facilities of the type you are familiar with such as those at Langley, Ames, or Lewis.

Mr. THOMAS. You have a very favorable rate. You have the TVA rate; do you not?

Dr. DRYDEN. Yes; the amount used is relatively small. It is an industrial factory operation. There is one small wind tunnel but no heavy user like the big wind tunnels.

Mr. RHODES. Mr. Chairman, would you yield?

Mr. THOMAS. Surely.

Mr. RHODES. On that item I notice that the rents are up from $2,585,000 to $15,399,000.

Dr. DRYDEN. The renting of data-reduction equipment is the biggest item in there.

PERSONNEL STRENGTH

Mr. THOMAS. I think they give you a pretty good breakdown a little further over on it.

Let us put the table on page 9 in the record. Here is a breakdown of numbers since you have been in existence, 1959, 1960, and 1961. This is by location. Your headquarters is: 1959, 428, then 683 for 1960, and 683 for this year; your Langley Center remains about the same; your Ames Center is about the same; Lewis is about the same; your Flight Center is at Muroc; that goes up to 416. Your Goddard Center goes up from 1,214 to 2,000; Wallops goes from 225 to 300; Huntsville from 100 to 5,500.

(The page referred to follows:)

	Number of employees at end of fiscal year			Appropriations		
	1959, actual	1960, estimated	1961, estimated	1959, actual	1960, actual	1961, requested
NASA Headquarters	428	683	683	$5,538,860	$7,549,300	$9,890,000
Langley Center	3,297	3,220	3,220	30,568,970	27,445,500	29,295,000
Ames Center	1,478	1,440	1,440	16,299,035	14,257,050	15,244,000
Lewis Center	2,783	2,736	2,736	27,215,227	24,840,200	25,724,000
Flight Center	336	416	416	3,154,208	3,038,150	3,679,000
Goddard Center	782	1,214	2,000	2,021,100	11,802,270	25,084,000
Wallops Station	171	225	300	1,356,820	1,700,100	2,678,000
NASA Huntsville		100	5,500		227,000	58,313,000
Western Office	7	32	46	94,815	338,930	515,500
AMRO Office	4	20	26	20,000	201,500	278,000
PMRO Office			6			59,500
Wright Office				17,265		
Total	9,286	10,086	16,373	86,286,300	91,400,000	170,760,000

HUNTSVILLE PERSONNEL

Dr. DRYDEN. The 100 at Huntsville are used in getting ready to take over the management before the transfer on July 1.

Mr. THOMAS. What was in Huntsville? I don't think you have a breakdown. What was Huntsville in 1959 and 1960 under the Army?

Mr. SIEPERT. I do not have the 1959 figure. As of the time the President made the decision, there were 4,213, I believe, who were directly responsible to Dr. von Braun. That is the so-called Development Operations Division. In addition to those 4,213, there were

somewhere between 1,300 and 1,500 persons, counting both military and civilian, who were in support of the Von Braun team, but were actually attached elsewhere, either the ABMA, the Redstone Arsenal, or the Army Ordnance Missile Command. Then, in addition, there were about 250 military specialists plus contractor employees who were carrying out contract assignments in Government facilities located on the Redstone Arsenal.

Mr. THOMAS. How did you arrive at this 5,500 figure if you increased it a thousand?

What type people did you increase over and beyond what the Von Braun team consisted of?

Mr. SIEPERT. We have actually reduced the manpower requirements from those which the Army had at the time. We made no basic change in the amount of civil service technical manpower that the Von Braun team had; namely, 4,200 or 4,300.

Mr. THOMAS. If I recall correctly, the Army is still carrying on some activities in space there.

Dr. DRYDEN. No, sir; not in space. They have the PERSHING missile.

Mr. THOMAS. Not in space. I beg your pardon. They are in the missile business.

Dr. DRYDEN. They are in the missile business.

Mr. THOMAS. So you evidently took all the supporting personnel?

Mr. SIEPERT. We took practically all of the scientific personnel and we are doing the PERSHING job for them.

REIMBURSEMENT FROM THE DEPARTMENT OF THE ARMY

Mr. THOMAS. Are they reimbursing you for that work?

Mr. SIEPERT. They will be; yes, sir.

Mr. THOMAS. Where do reimbursements show here?

Mr. SIEPERT. They do not show here. The Army had not determined at the time the budget was prepared how much that reimbursement would be.

Mr. THOMAS. Can your personnel figure of $170 million be reduced by your reimbursements then?

What is the approximate figure? You can straighten it out in the record later. Is it $1 million, $2 million, $5 million, or what?

Dr. DRYDEN. As I recall the present position, it is that the Army has not told us what this amount will be.

I don't think the amount has been negotiated as yet.

Mr. THOMAS. What is a fair figure? What is a fair guess?

Mr. SIEPERT. About $7 million was one figure that they talked about early.

Mr. THOMAS. About $7 million transfer?

Mr. HORNER. That $7 million is not included in the $170 million. I think a more accurate statement would be that any reimbursement would be over and above the $170 million. We probably will not negotiate the reimbursement amount.

Mr. THOMAS. How can you say that if you are performing services for it?

Mr. HORNER. Through the years, NACA has performed R. & D. services for the Department of Defense and our present law provides

for continuing those kinds of services. Where there are actual procurements incident to such services——

Mr. THOMAS. Put your finger on the new law that gives you that authority. Read it into the record, please.

Mr. HORNER. I do not have a copy of it with me, sir.

Mr. THOMAS. Under the old NACA, of course, if it was a development job for the aviation industry, you worked for John Public, aviation companies and the armed services without a contribution, but you are in a different classification now.

Mr. HORNER. I think it is in section 301(a):

> The National Advisory Committee for Aeronautics on the effective date of this section shall cease to exist. On such date all functions, powers, duties, and obligations and all real and personal property, personnel, and other than members of the Committee, funds and records of that organization shall be transferred to the Administration.

Mr. THOMAS. You are talking about one thing and we are talking about something else. We are talking about reimbursement by the Army for work that you are now doing for them in your new capacity. Your new capacity is entirely different than it was under the old NACA.

Dr. DRYDEN. The agreement is this work will be removed just as soon as it is feasible to do so. It is a situation much the same as when JPL was taken over. It was impossible to stop work of this kind abruptly; it is supposed to disappear within a period of a year or a year and a half.

Mr. THOMAS. Is it the contemplation of the Administration, the Space Administration and the Army, that the Army will transfer to you during the year a sum approximating $7 million for services performed for the Army during fiscal year 1961?

Mr. SIEPERT. The figure of $7 million is a ball park figure that came up very early in the negotiation before the Army had even decided how much work they were going to keep under Von Braun's own direction, as contrasted with putting it under the Army. You see, Mr. Chairman, the Army determined after this transfer decision of the President that the system management responsibility for any of their weapons development had to remain within the Army, whereas up until the decision this responsibility had been directly under Dr. von Braun. Now the $7 million figure represented an early estimate of money that the Army would presumably put into the PERSHING system work at Huntsville under Dr. von Braun in fiscal year 1961.

Mr. THOMAS. You are now doing that work for them?

Mr. SIEPERT. We will now be doing that work for them.

Mr. THOMAS. Come up with a reasonably accurate figure so we will know what we are doing. If you do any work for the Army you ought to get paid for it. That is the only way you can keep up with your business and the only way we can keep up with you.

Mr. SIEPERT. The Army-NASA agreements that were signed between Dr. Glennan and Mr. Brucker specifically do provide, and I quote this from page 5, "work on military weapons systems by NASA for the Army will also be on a reimbursable basis."

That is contrasted with research work of the sort that Mr. Abbott was talking about, where we work on research problems. This is

actually the building and development of a weapons system itself, a hardware job. It will be done on a reimbursable basis.

Dr. DRYDEN. Mr. Chairman, if we appear somewhat unresponsive and ignorant of some of these things, I again ask you to be reminded that as of yesterday the transfer was approved. There are an innumerable amount of details to work out between now and July 1 when the fiscal and personnel responsibility passes on to NASA. We have negotiated general agreements which have been put into the records of our authorization committee hearings. They could be put into your hearings if you would like to have them. They represent the ground rules under which we are working out such questions as the ones referred to yesterday—how much of the material in the storehouse goes to NASA; how much remains to the Army and this particular detail of the exact amount of Army work to be done is not settled as of this moment. It has not been settled as of this moment. It may not be possible to get it settled in time to get it into the hearings.

Mr. ULMER. I think it is fair to say, Mr. Thomas, that the NASA estimates before you are for NASA work; we have not assumed that any of this money would be used on reimbursable work for the Army.

Mr. THOMAS. If you are going to do work for the Army, it is a logical assumption this $170 million figure will show an offset, a reduction.

Mr. ULMER. There would be an additional amount transferred to NASA for the reimbursable work.

Dr. DRYDEN. The personnel at the time will be higher than 5,500 as long as the Army is asking us to do work for them.

Mr. THOMAS. When you finally reach and formalize your agreement this $170 million won't show a reduction?

Dr. DRYDEN. It will require more people than 5,500.

The additional people, whatever they are, will be supported by money from the Army. In other words, this budget is for NASA work. Whatever the Army asks us to do may take from zero to six or seven hundred people; they will be in addition to the NASA staff and those additional salaries will be reimbursed by the Army.

Mr. THOMAS. It will not be reflected one way or another in this $170 million?

Mr. ULMER. That is the point I wanted to make; yes, sir.

(NOTE.—According to the best but unofficial Army estimate as of March 17, 1960, a total of $6.14 million is planned for transfer by the Army for reimbursable procurements and services in connection with the PERSHING project. This sum is for additional work not reflected in the NASA estimates under either the S. & E. or R. & D. appropriation titles.)

Mr. THOMAS. Here is a breakdown of your personnel by your various installations on page 12. To make this chart complete, I think for your Huntsville station it would be well to put the number of personnel the Army had in for 1959 and 1960. You said it was around 4,500. That is what you received on the transfer date. You have already increased it by 1,000, is that correct?

(The information is as follows:)

REDSTONE ARSENAL INSTALLATION

Personnel strength

	June 30, 1959	June 30, 1960 [1]
Development Operations Division:		
Civil service	4,271	4,285
Military	292	190
Contractor	1,115	906
ABMA (other than Department of Defense): [2]		
Civil service	1,075	1,200
Military	108	130
Contractor	130	138
Redstone Arsenal: [3]		
Civil service	3,659	3,800
Military	916	815
Contractor		
Total on reservation: [3]		
Civil service and contractor	17,845	17,757
Military	4,421	4,120

[1] Strength figures as of Feb. 29, 1960, and estimated by NASA to be identical with end of year figures.
[2] Includes 1,300 to 1,500 man-years estimated to be in support of the Development Operations Division.
[3] Includes ARGMA and Guided Missile School.

Mr. HORNER. There will not be a thousand new hires at Huntsville.

Mr. THOMAS. Let me repeat exactly what you said. You took over from Von Braun 4,500 people; supporting personnel, regardless of what it was, all Army or some civilian contract personnel, added up to about what, 1,000?

Mr. ULMER. Approximately.

Dr. DRYDEN. I think we are getting confused by the technicalities.

Mr. THOMAS. Then I want to know how many of the total supporting personnel the Army had and how many they kept for their own use; and how many you are supporting either by this appropriation or by transfer.

Mr. SIEPERT. According to the best information we could get from the Army at the time we were negotiating, the Army was providing in technical and management support, from Army service units outside of Dr. von Braun's group, from 1,300 to 1,500 people, both military and civil service people. According to our estimates, we felt that we could do the same job for Von Braun's technical team with about 1,200 people; in other words, fewer people. However, when we came to negotiate with the Army on the number of people that could actually transfer to us, the Army at this point insisted and showed that they had a continuing Army need to carry on certain Army missile functions and they needed certain of these people.

The final agreement was that 815 positions in the Army would move to us. This, in effect, means then that we are asking for 400 additional positions. That is, new positions in the management and technical support side at Huntsville.

Mr. THOMAS. Four hundred rather than a thousand.

Mr. SIEPERT. Yes, the difference between the 1,200 that we estimated we would need to support Von Braun and the 815 that they would actually supply us; 385 is the actual difference.

PROPOSED STAFFING FOR HUNTSVILLE

Mr. THOMAS. Which page is the table for Huntsville?

Mr. ULMER. 13–26.

Mr. THOMAS. Where will you put these additional 400 people? In your legal office you have nine people. The highest is a grade 15. The Director's Office is one of your excepted positions. He has a deputy that is in an excepted position. There are two assistants. They are excepted. Ten other people makes a total of 15 in his office. Five of them are excepted positions.

General OSTRANDER. I may be able to help here, Mr. Chairman. Largely speaking, these technical and administrative support people, which is the 1,200 that Mr. Siepert spoke of, will go in the four boxes on the right-hand side of the second line, plus——

Mr. THOMAS. "Technical Office, financial management, personnel and administration," is that it?

General OSTRANDER. Yes, sir, plus the four offices shown attached to the Office of the Director.

Mr. THOMAS. Are they going in the housekeeping activities here, that is, financial management, personnel, procurement, contract, or are they going into technical services?

General OSTRANDER. These are the functions which previously were performed for Dr. von Braun's Development Operation Division by other activities of the Army, other sections of the Army.

Mr. THOMAS. You have "Personnel administration," 268 people to take care of 5,500.

Mr. SIEPERT. No, sir; only 64 people are in the personnel field. These other functions cover office services of various types, communications, security, duplicating, photographic, and mail and records.

Mr. THOMAS. Are these the old salaries scheduled under the Army or under NASA? Which is it?

Mr. ULMER. These are the Army salary schedules, sir.

Mr. SIEPERT. Agreements provide that to the extent we hire Army personnel, we are hiring them on a lateral transfer basis.

Mr. THOMAS. Here in this very vital laboratory I see more 15's than I do 17's and 18's and excepted positions.

Dr. DRYDEN. The Army has very few. The authorization bill just passed by the House has provided additional excepted positions to make the Huntsville proportion of such positions the same as the other laboratories in NASA. The Army had very few 16's, 17's, 18's, and Public Law 313's.

Mr. THOMAS. You are taking it out of my mouth. The Army was operating the personnel business much cheaper than NASA, doing the same or similar work, or certainly the very vital part of the work. The chart clearly indicates that, does it not?

TECHNICAL SERVICES OFFICE

You say the 400 people are now going into housekeeping work, personnel administration, financial, technical services. Technical

services could not be classed as housekeeping work. What is the function of this 665 people?

Mr. SIEPERT. That entire group is concerned with the engineering and plant support to keep this $100 million facility running. This covers shops, people, and an engineering function that determines the design requirements of any construction at Huntsville. It involves safety, which is a very major problem down there, and finally, plant maintenance, plumbers, carpenters, and the like.

Mr. THOMAS. These four boxes are virtually housekeeping activities. Certainly in your ballistic laboratory, computation laboratory, fabrication and engineering lab, guidance and control lab, you have the meat in the coconut. They are your scientific people.

Dr. DRYDEN. The scientific people are down in the last two lines, principally, with some in the project offices which are off to the left. The numbers in the four boxes that you have just been talking about and the four attached to the Office of the Director add up to 1,178, which is roughly the 1,200 that we were talking about.

Mr. THOMAS. There are 123 in procurement, personnel, and administration, office services, 268. There are almost 400; in financial management there are 89; technical services, safety engineering, sanitary engineering, equipment and maintenance, 665.

Mr. SIEPERT. Mr. Chairman, I omitted one very large function, which is in the Technical Services office. My recollection is that it actually has 326 people in it, or almost half of this total thing. This is a thing called T.M. & E., technical materials and equipment, and it is a very complicated and extensive stockroom, which stocks the inventory of materials and components needed to build these rockets.

There are 326 people in that one function. The position titles do not show here, as they are all low-grade, wage board and GS personnel.

Mr. THOMAS. What is their civil service rating?

Mr. SIEPERT. I do not know what the average is.

Mr. THOMAS. These are component stock clerks which you will find in any big garage or any big installation of any type.

Dr. SIEPERT. It is a stockroom such as industrial plant would have, yes. That is half that number.

Mr. THOMAS. Out of your 400 new employees that you are adding here you are certainly not adding any scientists who will be engaged in research.

Dr. DRYDEN. We are adding 400 people to replace people who have been doing Dr. von Braun's work and who the Army thinks they must keep to carry out their own functions. We are not providing any additional numbers of people for the same function. In fact, it is a few hundred less than the Army is presently using to do the same job.

Mr. THOMAS. We have already put the table in the record on page 13–26, showing the breakdown at Huntsville.

NASA ORGANIZATIONAL CHART

Put the overall chart appearing before that in the record, page 13–1.

(The page referred to follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. THOMAS. This gives you a breakdown of your entire operation. I notice in the overall chart the Office of Information. That is apparently located in the Washington office.

Dr. DRYDEN. The upper part of this chart is the breakdown of headquarters.

Mr. THOMAS. Then I look down below. You have the Technical Information Division.

Dr. DRYDEN. That is the scientific and technical reports.

Mr. THOMAS. Where is this located? Where is this Division? This is still in the Washington office, is it not?

Dr. DRYDEN. Yes, sir.

Mr. THOMAS. You have two vacancies in two divisions, Assistant Director for Aerodynamics and Flight Dynamics. What about Office of Research Grants and Contracts? Is that vacant?

Mr. ABBOTT. No, sir.

PROPOSED STAFFING FOR NASA HEADQUARTERS

Mr. THOMAS. We shall take a look at the big chart outlining your headquarters. It shows the Office of Public Information, in the district headquarters, 34. You have Technical Information, 37, or a total of 71 people.

Dr. GLENNAN. The Office of Technical Information, Mr. Chairman, handles the output of this organization. Our product is scientific information and the publication of these is about the only way in which we can give to the other services, other agencies of Government and to industry the results of the millions of dollars that we are spending in research.

Mr. THOMAS. You mean these other 34 people cannot do that?

Dr. GLENNAN. These 34 people, if you will look at them, or a very large proportion of these——

Mr. THOMAS. You have one excepted position in your 34. You do not have anything but a 15 in your Technical Information Division. It looks to me the 34, with at least 6 of them grade 15, ought to be able to handle it. You have one 15 and two 13's out of the 37 in your Technical Information and 34 others.

Dr. GLENNAN. The problem of dealing with the public——

Mr. THOMAS. We are supposed to have a little knowledge on that on this side of the table, dealing with the public. Some of us have been doing that for a long time.

Dr. GLENNAN. You would understand why we need this office.

Mr. THOMAS. We might be able to give you a few pointers in that.

Dr. GLENNAN. I will take them any day. You would understand why we need the office then.

Mr. THOMAS. You certainly do not need this many.

Do you have any other vacancies in your planned setup other than this one for Assistant Director for Aerodynamics and Flight Mechanics?

Mr. ULMER. I think there are no other major position vacancies of that type. There are, of course, the normal turnover vacancies that occur.

Mr. THOMAS. What is this increase over last year? Is it 150?

Mr. ULMER. There is no increase over the planned end of the current fiscal year strength, Mr. Thomas. If you will recall, we discussed the question of the 150 additional positions for headquarters during the hearings on our supplemental.

Mr. THOMAS. You had 533 and you are seeking 683. That is 150, is it not, against 428 for 1959?

Dr. GLENNAN. You will recall in the supplemental we asked for advance approval on that and that you, in reporting out the bill, agreed to 75. The 75 are half of that 150 you see there. We told you at the time that this was simply an advanced recruitment of management personnel made necessary by the fact that we are taking over the Marshall Space Fight Center. Incidentally, it was just announced that the NASA Huntsville facility will now be known as the Marshall Space Flight Center.

Mr. THOMAS. Marshall Space Flight Center.

Dr. GLENNAN. For George C. Marshall, General of the Army.

Mr. THOMAS. These jobs were provided in the supplemental, then. I had forgotten.

Mr. ULMER. They were discussed in the supplemental, sir. The status at the present time is you authorized 75 of them. The Senate Committee has approved 150. The bill has not yet passed the Senate.

Mr. THOMAS. Anyway, your supplemental figure is included in your 683 for 1961.

Dr. GLENNAN. That is right, sir.

Mr. THOMAS. We have gone into these tables before showing your increases. They were gone into carefully in the supplemental. I see no point in adding this now.

Which is your next laboratory in point of sequence? Is it Langley?

OFFICE FOR U.N. CONFERENCE

Mr. JONAS. Mr. Chairman, before you go to that, may I ask a question?

Mr. THOMAS. Yes, Mr. Jonas.

Mr. JONAS. Do you have a full-time assistant at the United Nations?

Dr. GLENNAN. No, sir.

Mr. JONAS. "Office for U.N. Conference."

Dr. GLENNAN. Dr. Dryden perhaps will answer that.

Dr. DRYDEN. This office at present consists of an assistant to me and six others attached to my office. The General Assembly of the U.N. voted to have a conference on the peaceful uses of outer space, either in 1960 or 1961. They also appointed a committee on the peaceful uses of outer space. Negotiations are underway between our State Department and the other members to come to a determination as to which year the conference will be held and what its contend will be. When this conference is held we at NASA will be responsible for organizing the U.S. participation and making a good showing there. We have begun a planning activity to this end at the present.

Mr. JONAS. You have about $50,000 in here for personal services.

Dr. DRYDEN. Yes. There are four people and a secretary.

Mr. JONAS. Do you not have a separate office organized for that?

Dr. DRYDEN. Yes. If this conference is held, judging from the experience of the AEC——

Mr. JONAS. Why couldn't the Office of International Programs handle that? It would be for them a little extra work.

Dr. DRYDEN. The Office of International Programs is a coordinating office. The planning for this conference involves continuous consultation with the State Department and it will be a very major undertaking if the conference is held. Judging from the experience of the AEC it will be necessary for us to assign upward of 100 people to that job if it really goes forward.

Dr. GLENNAN. This reflects the experience which the AEC had, Mr. Chairman, in the two Geneva Conferences on Atomic Energy.

Dr. DRYDEN. Our Government has been pressing to hold this conference this fall and time is very short. We have had to make plans to be able to move ahead very, very promptly if the decision should be to hold this meeting this fall.

Mr. JONAS. That is all.

Mr. THOMAS. Off the record.

(Discussion off the record.)

PROPOSED STAFFING FOR LANGLEY RESEARCH CENTER

Mr. THOMAS. The table on page 13–20 deals with Langley. It shows that Langley had 3,220 people in 1960. You are not increasing it.

You have 3,220 this year. Can you briefly describe the activities at Langley? You have 25 percent of your people engaged in research on manned airplanes.

Mr. ABBOTT. Yes, sir. The activity at Langley is directed primarily these days toward the problems of structures and materials in the environment in which they will be exposed in space and during reentry, together with the associated aerodynamics and aerospace mechanics.

Mr. THOMAS. Here are 3,200 people. They were set up and equipped and trained with equipment to do airplane work. You have been out of the airplane business now for about a year and a half. Why has there not been a reduction in your personnel load? You have a wagonload of money back here for construction to go in the laboratory, including modernization. You give us the justification for it, it has to be done because what is there now is not fitted to your workload. How come you have all these people here?

Mr. ABBOTT. We have all these people here because the research problems in this new technology are greater and more pressing than they ever were in aeronautics and the skills of these people are needed to get solutions to these problems before we put all the country's money down a rathole trying to develop new vehicles for which the research information is not available.

This is the primary reason.

Mr. THOMAS. These people were not working on space. That is what your new agency was set up for.

Mr. ABBOTT. I would like to point out, sir, there was nobody in this country working on space just a short while ago. These people are well equipped and better trained to work in space than most others.

Mr. THOMAS. In other words, you take the position here is an organization and you weren't going to reduce it. You were going to balloon it up regardless of the workload for the time being and let them sit there until you build equipment?

Mr. ABBOTT. No, sir.

Mr. THOMAS. Explain it, then. How do you justify this equipment item you have here when you say it is not suited to your needs?

Mr. ABBOTT. Some of the equipment is not suited to our needs.

Mr. THOMAS. Would it not follow that some of your people were not suited to your needs?

Dr. GLENNAN. They can be retrained.

Mr. ABBOTT. They can be retrained. Those who cannot be retrained have left. There has been some turnover.

Mr. THOMAS. I do not see any of them leaving here. You had 3,220 last year and you have 3,220 this year.

Mr. ABBOTT. I am speaking about individuals rather than the total.

Dr. DRYDEN. The rate of modernization of facilities represented by the amount of money in this bill, Mr. Chairman, is no higher—if anything, it is somewhat less than it ever was while we were doing aeronautical work. The reason that the Space Agency was built around NACA as a nucleus was because we did have the people who had the skills suitable for space.

Mr. THOMAS. You have it just about to the point of perfection for aeronautical work. You could not get it any better than you had it.

Dr. DRYDEN. I think there is still plenty to do in the aeronautical field. That is another question. We have within the present NASA most of the people in the Government who had the skills necessary to work in space. We started with those in the old NACA who had the background, for example, in structures and materials suitable for use at high speeds, and in all the rest of the related problem areas. We took the people in the Navy who had been carrying on the VANGUARD program—a part of the civilian space program. We now have taken the people in the Army who were carrying on the large booster work as a part of the civilian space program so that we do now have a collection of the most highly qualified people in the country that were within the Government service, and the best facilities. In their support we enlist the resources of the defense industries of the country that used to build airplanes and are now building missiles and space vehicles, and the great electronic companies who have turned their attention to the kinds of equipment needed in the space program. As we have mentioned, about three-quarters of the money that you are assigning to the space work is spent on the qualified people who are outside of the Government service and about one-fourth of it, on the people in the Government service who are most qualified to enter a field of activity which was nonexistent before 1957.

Mr. THOMAS. I need one or two more fingers for these charts. What is your construction program here at this installation?

Dr. DRYDEN. A little over $11 million.

Mr. THOMAS. You have a leadtime in there for those facilities of about 24 months?

Dr. DRYDEN. That is about right.

Mr. THOMAS. What will these people be doing? You said the only reason you want this $11 million worth of new construction is because what you have there is not suited for your needs. It will take 24 months to build it.

Mr. ABBOTT. I would like to point out there has been extensive reorganization and changing activity at the center. The flight research work on conventional airplanes there has been stopped completely, the Aerodynamics Division has been disbanded.

Mr. THOMAS. What became of the people?

Mr. ABBOTT. They have done several things.

Mr. THOMAS. The records do not show that they departed.

Mr. ABBOTT. We had to increase the complement at the Flight Research Center at Edwards to take care of the X–15 airplane. Some of the people went there. Many of them have been retrained in other activities. They had skills which made them subject to a comparatively easy retraining.

Some of them individually are no longer with us at all and have been replaced.

Mr. THOMAS. How many vacancies did you have at Langley on January 1?

Mr. ULMER. Actually, at Langley we had no vacancies. As Mr. Abbott pointed out, there is a transition where people were dropped from Langley and the positions transferred to the high-speed station. That table on page 9 that you referred to, in the 1960 and 1961 column——

Mr. THOMAS. If they were dropped, why don't your tables show it?

Mr. ULMER. I think they do. On page 9, if you will look at the 1959 column, you will see 3,297 dropping to 3,220 in 1960.

Mr. THOMAS. 3,297 in 1959, down to 3,220 and you have had it there for 2 fiscal years.

Mr. ULMER. We are in the fiscal year 1960 and we will be at 3,220 by the end of fiscal year 1960.

Mr. THOMAS. My table on page 12 shows 1960 fiscal year you had 3,220 and fiscal year 1961 you have 3,220.

Mr. ULMER. Yes; the 1959 figure which is the start of fiscal year 1960 is 3,297. During the year we will come down to 3,220. At the present time we have 3,215, on the rolls at Langley. This reduction is taking place at Langley, at Ames and at Lewis. These reductions are offset by an increase at the Flight Center that Mr. Abbott spoke of in connection with the X–15 program.

Mr. THOMAS. In 3 years you show a reduction from 3,297 down to 3,220.

Mr. ULMER. Yes, sir.

Mr. THOMAS. That is 79 people, less than 1 percent.

Dr. GLENNAN. One of the few agencies of the Government that can say that.

Mr. THOMAS. What is that, one-fourth of 1 percent?

Mr. ULMER. It is over 2 percent, I think.

Dr. GLENNAN. At the same time, our business has gone up five, six, sevenfold.

Mr. THOMAS. What is that, Doctor?

Dr. GLENNAN. At the same time, our responsibilities have gone up five, six, or sevenfold, sir.

Mr. THOMAS. Spell that out, please, sir.

Dr. GLENNAN. At the time that I came aboard——

Mr. THOMAS. It has gone up a hundred percent. You were taken out of the airplane business and put in the space business. On the basis of that, you are a hundred percent——

Dr. GLENNAN. NACA's budget at the time we came aboard was $100 million. We are asking, 18 months later, or 21 months later, for $915 million. That is ninefold.

Mr. THOMAS. That is dollarwise. What about your units?

Dr. GLENNAN. Personnel has gone up twice, of which all except about 1,500——

Mr. JONAS. You misunderstand the chairman. He knows it has gone up. He wants to know what all those people are doing.

Mr. THOMAS. He did not misunderstand.

Dr. GLENNAN. I was with the chairman one day down in Huntsville. He saw what they were doing.

Mr. THOMAS. He did not misunderstand.

Answer Mr. Jonas' question.

Dr. GLENNAN. I think I did. I am not sure.

Mr. JONAS. I just said the chairman had the idea you had too many people down at Langley.

PROPOSED STAFFING FOR AMES RESEARCH CENTER

Mr. THOMAS. Let us take a look at Ames.

In 1960 you had 1,440, 1961, you want 1,440 people. Briefly describe your activities there.

Mr. ABBOTT. The activities at Ames are primarily in the field of very high speed aerodynamics, with emphasis also on automatic stability and control, including trajectory control, and also a certain amount of research relating to materials, particularly with regard to the reaction of materials at very high temperatures during reentry—not strictly materials research, but the reaction of materials to their environment during reentry; and impact work, such as from meteoroid impact on vehicles in space for which we use very high speed guns.

Again, conventional airplane flight testing at Ames has been discontinued and the work has been largely reoriented toward space activities.

Mr. THOMAS. Is your Edwards facility complementary to this one? What do you do at Edwards?

Mr. ABBOTT. Edwards is the only place where we conduct flight tests on conventional airplanes. The activity there is to a very large extent, over 90 percent, on the X–15.

Mr. THOMAS. I thought you had some engine testing facilities at Edwards.

Dr. DRYDEN. The engine test facilities at Edwards are Air Force facilities.

Mr. THOMAS. Not yours?

Mr. ABBOTT. No, sir.

Mr. THOMAS. Not NASA's?

Mr. ABBOTT. No, sir.

Dr. SILVERSTEIN. There is a very small JPL solid rocket stand at Edwards.

Dr. GLENNAN. And a liquid rocket stand.

General OSTRANDER. I think you had reference to my remarks where we were modifying some of the Air Force stands.

Mr. THOMAS. No. This one has been built as well as I remember 2½ years. I think you are looking for some money to modify it.

Mr. HORNER. That is right. That is the facility used in connection with the JPL program.

Mr. ABBOTT. The engine test facilities are completely separate.

Mr. THOMAS. You are not going to reduce this? You have a lot of construction money here. Some of these buildings will not be ready for 27 months.

Mr. ABBOTT. For Ames?

Mr. THOMAS. Yes.

Mr. ABBOTT. We are requesting only $980,000 for construction at Ames.

Mr. THOMAS. What are the items?

Dr. DRYDEN. One item of centrifuge equipment.

Mr. THOMAS. When will that be ready? What is the lead time on that? It is the shortest period of time as I remember this item.

Mr. ULMER. It is very short, 8 months.

PROPOSED STAFFING FOR LEWIS RESEARCH CENTER

Mr. THOMAS. In 1959 you had 2,783 personnel at Lewis, in 1960, 2,736, and for 1961 you ask for 2,736.

What about your Lewis Laboratory?

Mr. ABBOTT. The work at Lewis has been reoriented almost completely from jet engine work which they were doing just a short while ago.

Mr. THOMAS. You were engaged exclusively in fuels and power development here.

Mr. ABBOTT. We are still engaged exclusively in fuels and power development, but now in connection with rockets, in connection with power supplies for space craft rather than with airplane engines.

Mr. THOMAS. How much construction do you have here?

Mr. ABBOTT. We have two items.

Mr. THOMAS. You have a couple of laboratories.

Dr. GLENNAN. $9,100,000.

Mr. THOMAS. Your leadtime is 2½ years.

Mr. ABBOTT. We have an energy conversion laboratory and a basic materials research laboratory; yes, sir.

Dr. GLENNAN. Twenty-seven months on one, and fifteen months on the other.

Mr. THOMAS. You will keep all this personnel during that time, waiting for your new facility?

Mr. ABBOTT. We are not keeping personnel waiting for new facilities. We are very short on personnel, sir.

Mr. THOMAS. What do you need with the new facilities?

Mr. ABBOTT. When we get the new facilities, we are going to have to stop doing things that we are doing now. The lowest priority things will have to go to permit us to man the new facilities.

Dr. DRYDEN. Unless you provide the additional personnel required when the time comes; it depends on the state of the space program at that time.

PROPOSED STAFFING FOR FLIGHT RESEARCH CENTER

Mr. THOMAS. Do you think that is the answer. You have a flight research center.

Put 13–23 in the record.

(The chart may be found on page 302.)

Mr. THOMAS. Where is this located?

Mr. ABBOTT. This is located at Edwards Air Force Base, Calif., and their main activity, in fact, almost their only activity at the moment, is on the X–15 airplane.

Mr. THOMAS. What was the personnel here in 1958 and 1959? I remember when you had less than a hundred out there.

Now, you have around 400.

What is the total personnel at the flight center?

Mr. ULMER. 416 at the end of this year.

Mr. THOMAS. 336, 416, 416 for 1959, 1960, and 1961.

Repeat what they do for the record.

Mr. ABBOTT. They are working on the X–15 airplane. As you know, this is a cooperative program. The airplanes are being turned over to us. We already have the first one and two others will be received this year. We are going to conduct an extensive series of flight research tests with these three airplanes.

Mr. THOMAS. What is the altitude on the X–15 and what is the speed?

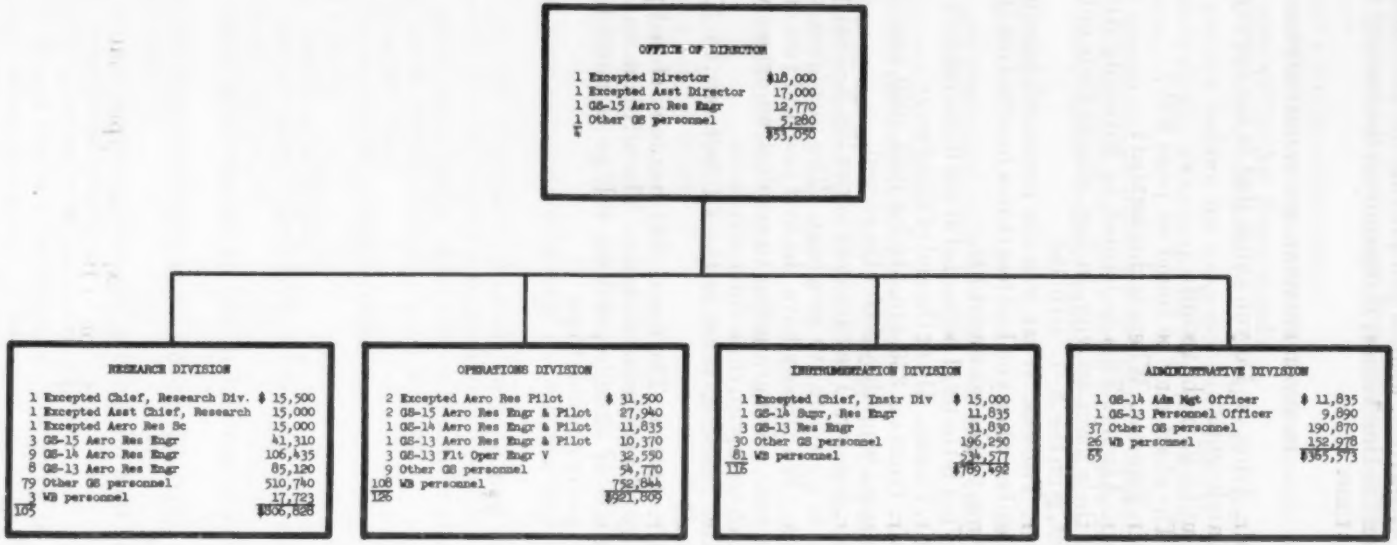
Mr. ABBOTT. The speed that has been stated publicly is in the vicinity of 4,000 miles an hour. The airplane was designed to reach an altitude of 50 miles, and we will go as much higher than that as it will prove possible to go.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROPOSED PERSONNEL STAFFING CHART

FISCAL YEAR 1961

FLIGHT RESEARCH CENTER


OFFICE OF DIRECTOR
1 Excepted Director $18,000
1 Excepted Asst Director 17,000
1 GS-15 Aero Res Engr 12,770
1 Other GS personnel 5,280
4 $53,050
RESEARCH DIVISION
1 Excepted Chief, Research Div. $ 15,500
1 Excepted Asst Chief, Research 15,000
1 Excepted Aero Res Sc 15,000
3 GS-15 Aero Res Engr 41,310
9 GS-14 Aero Res Engr 106,435
8 GS-13 Aero Res Engr 85,120
79 Other GS personnel 510,740
3 WB personnel 17,723
105 $806,828
OPERATIONS DIVISION
2 Excepted Aero Res Pilot $ 31,500
2 GS-15 Aero Res Engr & Pilot 27,940
1 GS-14 Aero Res Engr & Pilot 11,835
1 GS-13 Aero Res Engr & Pilot 10,370
3 GS-13 Flt Oper Engr V 32,550
9 Other GS personnel 54,770
108 WB personnel 752,844
126 $921,809
INSTRUMENTATION DIVISION
1 Excepted Chief, Instr Div $ 15,000
1 GS-14 Supr, Res Engr 11,835
3 GS-13 Res Engr 31,830
30 Other GS personnel 196,290
81 WB personnel 534,277
116 $789,492
ADMINISTRATIVE DIVISION
1 GS-14 Adm Mgt Officer $ 11,835
1 GS-13 Personnel Officer 9,890
37 Other GS personnel 190,870
26 WB personnel 152,978
65 $365,573

Dr. GLENNAN. That is twice as high as any other manned airplane that has thus far flown.

Mr. ABBOTT. More than twice. The design speed and the design altitude is more than twice as high as any other manned airplane.

Mr. THOMAS. What is the economical speed of the plane?

Mr. ABBOTT. In the immediate future I foresee an economical speed for airplanes in the vicinity of 2,000 miles an hour, with a growth potential to 2,500 to 2,700 miles per hour.

Mr. THOMAS. What would be more or less a probable working altitude, 25 or 30 miles rather than 50 miles?

Mr. ABBOTT. For economical airplanes like that, I would think in the general vicinity of 70,000 to 80,000 feet.

Mr. THOMAS. 70,000 to 80,000 feet.

Mr. ABBOTT. Yes.

Mr. THOMAS. I thought I understood you to say a while ago 50 miles.

Mr. ABBOTT. The X–15 is designed to reach an altitude of 50 miles.

Mr. THOMAS. But a more probable altitude would be your seventy or eighty thousand feet?

Mr. ABBOTT. For very much slower airplanes; yes, sir.

Mr. THOMAS. But this particular research plane is capable of going higher distances?

Mr. ABBOTT. Yes, sir. It is capable of going very much higher distances at very much higher speed.

Mr. THOMAS. Has this flown on its own power yet?

Mr. ABBOTT. Yes, several times.

Mr. THOMAS. It was taken up and dropped and then it came down under its own power?

Mr. ABBOTT. It is always carried aloft by the B–52, Mr. Thomas. Then it is dropped. The rockets are started after it is dropped from the B–52. This has been done several times, several times for two airplanes.

Mr. THOMAS. I remember reading about it twice or maybe three times. On each occasion it was taken aloft by a mother plane.

Mr. ABBOTT. Yes, sir.

Mr. THOMAS. It stayed in the air 2 or 3 minutes?

Mr. ABBOTT. It is a little longer than that. It is on the order of 10 to 12 minutes.

Mr. THOMAS. How much longer are you going to continue this activity that is costing you around $3,679,000 in 1961 for personal services alone; and you haven't put in your other research or development costs, but personnel costs are listed here.

Mr. ABBOTT. I can foresee 2 years for certain, Mr. Thomas. Beyond that, I do not know.

Mr. THOMAS. What is this installation cost, wrapped up, for salaries, expenses, other objects and everything? What is NASA's part?

Mr. ULMER. $4,729,000; $1,050,000 under the "Research and development" appropriation, and the $3,679,000 that you mentioned under the "Salaries and expenses" appropriation; there is no construction for that station in 1961.

Mr. THOMAS. 3.6 million, S. & E.

Mr. ULMER. Yes, and $1,050,000 under R. & D.

Mr. ABBOTT. I might mention that it is estimated that the support which the Air Force would be supplying for this X–15 although we are flying it, will be approximately twice our direct costs on the airplane.

Mr. THOMAS. Twice?

Mr. ABBOTT. They will be putting some $7 or $8 million a year into support.

Mr. RHODES. Mr. Chairman, may I ask one question?

Mr. THOMAS. Yes, sir.

Mr. RHODES. Did you mean the powerplant of the X–15 will only remain in operation for 10 to 12 minutes or did you mean it would remain in flight for 10 to 12 minutes after it is dropped from the mother plane?

Mr. ABBOTT. I would have to look these times up to give them to you exactly. The time of operation of the powerplant is less than that. It is on the order of 5 or 6 minutes at full throttle. It depends, of course, on how fast you burn up the propellants. When the propellants are all gone, then you are through with the power. Then the time remaining is just the time to glide back down to land and at these speeds, the rapid sinking speed of that airplane, it is not very long.

Mr. RHODES. It must get down pretty fast if your flight is only 10 or 12 minutes. That is my point.

Mr. ABBOTT. I think I underestimated the total flight time. It depends, of course, on the mission. It runs more like 15 minutes.

Mr. RHODES. Can it get up to 50 miles in altitude with the powerplant only in operation from 5 to 6 minutes?

Mr. ABBOTT. Yes, sir. We hope it will go very much higher than that. This is merely the design point.

Dr. GLENNAN. It is just a rocket, a straightforward rocket.

Mr. THOMAS. But it is manned?

Dr. GLENNAN. Yes.

Mr. THOMAS. Mr. Rhodes, did you hear the last? It is a rocket but it is manned.

Mr. RHODES. I know.

Mr. THOMAS. I would not want to be that man.

What fuel does this plane use?

Dr. DRYDEN. It uses liquid oxygen and ammonia—anhydrous-ammonia.

PROPOSED STAFFING FOR GODDARD SPACE FLIGHT CENTER

Mr. THOMAS. Let us take a look at the new Goddard Center.

Mr. THOMAS. The organizational chart shows that you are increasing your personnel from 1,214 to 2,000. What is the activity of this new center?

You have a lot of construction going on out there this year, I notice. This is your new one. This deals purely with your announced activities? You did not inherit this? You built this. It is your own handiwork.

Dr. SILVERSTEIN. The Goddard Center has the responsibility within this framework of our space flight programs for handling the sound-

ing rocket and the satellite program. You recall this morning that the outline of the program includes the sounding rocket—about 100 sounding rockets a year—and the scientific flights as well as the application of the satellites in manned space flight. From the standpoint of our field activities, the group carrying on this work——

Mr. THOMAS. If my memory serves me correctly, the figure you have in the justifications is 90 sounding rockets a year, 10 of which are going a way upstairs and, perhaps, 20, and 70 more downstairs, is that correct?

Dr. SILVERSTEIN. Yes, sir.

Mr. THOMAS. You may proceed.

Dr. SILVERSTEIN. I think the chart which I showed the committee this morning had over 100, but I think these figures adjust themselves between the time of our initial planning of the program and as we move along with the program.

This group at Goddard comprises the scientific talent, the scientists who are essentially experts in these upper air sciences.

WALLOPS STATION

Mr. THOMAS. Let's take a look at your situation at Wallops. You go from 225 to 300 employees.

How does Wallops fit into the picture? This is your handiwork, too, is it not?

Dr. SILVERSTEIN. Yes, sir. The Wallops Station is utilized for launching sounding rockets, test vehicles, and small satellites. The Goddard Center will be the data center for all NASA space operations; it will also be responsible for payloads, primarily for earth satellites, and for directing the manned space flight program. Within the chart you will see there is one division under the Assistant Director for Tracking and Data Systems. It is these people who are responsible for bringing into the Goddard Center the electronics tracking information and other data from our space operations.

GODDARD CENTER

Mr. THOMAS. You really set this up as a data processing center, did you not?

Dr. SILVERSTEIN. Yes, sir.

Mr. THOMAS. Now you are going to build a couple of laboratories. Your last justification was to the effect that it was going to be your data processing center.

Dr. SILVERSTEIN. That was part of our original justification.

Mr. THOMAS. Now you come in with two new laboratories and 800 people.

Dr. SILVERSTEIN. I think you will find in the original justification that we had intended to center the activity relating to data processing there. I do not recall the wording exactly, but this was certainly our intent.

Dr. GLENNAN. It was called the space flight control center.

Dr. SILVERSTEIN. We have intentions of putting this work here and the people here are going to be responsible for monitoring the contract activities which will be carried on with industry and with the various universities.

Mr. THOMAS. What will your 1,200 people be doing and what will your 800 additional people do here?

What is the nature of their activities? You are going to build a laboratory or two laboratories

Dr. SILVERSTEIN. The 1,200 people we have currently are engaged partly in the laboratory, doing scientific work in the development of the instrumentation and in the development of the flight package.

Mr. THOMAS. Please turn to your chart which appears on pages 13–24 of the justification and show us where your 1,200 people are now and where you will put these 800 additional.

Dr. SILVERSTEIN. This chart was made up for our total of 2,000 people. We have currently some 538 people, I think, in our manned space flight activity. These are people who are housed at our Langley Center and are responsible for the overall Langley program development.

In Washington here, at some three different areas, we have housed the remaining people—some 700 approximately. About 120 of these are in the activity of processing the procurement documents and contracts for some several hundred millions of dollars; they will have to process during the period of 1960–61 all the contracts with industry and with the universities.

We have some 338 people in this Division called Assistant Director of Space Sciences and Satellite Applications. These people are the scientists, and the support for the scientists, who prepare the sounding rocket payloads and prepare the satellite payloads that are flown on some of the vehicles. They are responsible for the scientific followup of the satellites, instrumentation, and packaging.

Mr. THOMAS. What is the laboratory which you want to build? What are the people doing now? It will take 18 months to build the laboratory.

Dr. SILVERSTEIN. This ties in with the developments in our space program. Currently, we are working with small vehicles and fairly small payloads. They are about this size [indicating] and they weigh about 95 pounds. This is the biggest payload we can put up with the vehicles we have now, but as our program moves along, about the middle of 1961, we will get into scientific satellites which will weigh up to 5,000 pounds. These satellites will be carried on our AGENA vehicle, perhaps, up to 8,000 pounds. Our laboratories will provide us the capability for doing envirnomental tests and putting together and checking out these bigger satellites.

Mr. THOMAS. But you will not have room for these people to work for 2 years because you will not get your laboratories built under 27 months.

Dr. SILVERSTEIN. I think they are scheduled to be built in about from 15 to 18 months. That is about the time they will be needed.

Mr. THOMAS. What are you going to do with your people before then?

Dr. SILVERSTEIN. Currently, our people are working very hard. We have part of our people located at NRL and we are building——

Mr. THOMAS. That is only 1,200 of them. We are talking about the additional 800 you expect to have by July 1.

Dr. SILVERSTEIN. Yes. In previous years we have received funds to initiate construction at our Goddard Center. Three buildings are

going up which will become available about the middle of this year, as reported by Mr. Horner yesterday. We will use these buildings and they will house some approximately 1,100 to 1,200 of the people that we are going to bring aboard.

Currently we are housing about 700 of our people at isolated spots such as NRL, the naval receiving station and in a building out at Silver Spring right in the Washington area here. What we are going to do is to bring these people together. We have 538 people who are now located in buildings at our Langley Center. This is the group which is doing our manned space flight program. So, basically, the job we have had to do is to create a staff to do this work and it is absolutely essential in order to get the job done that we have this staff and, secondly, we will have to go about the process of bringing the staff together where the work can be done efficiently and effectively at a central center by cross-fertilization.

Mr. THOMAS. How many vacancies as of January 31 did you have in your 1,200-man organization?

Dr. SILVERSTEIN. I think the vacancies were very small.

Mr. ULMER. There were 37 vacancies.

Mr. THOMAS. How does your personnel load break itself down between people with scientific and engineering backgrounds and administrative people in your organization?

Dr. SILVERSTEIN. I do not have that breakdown at my finger tips but I can provide it for the record.

Mr. THOMAS. Do you have an approximate figure, and then you can straighten it out for the record?

Dr. SILVERSTEIN. Yes. Out of this total of 1,214 there would be about 900 in the category of technical and scientific and 300 who would be considered to be wage board and supporting administrative personnel.

Mr. RHODES. Mr. Chairman, he just mentioned the breakdown of the 1,200. Do you not want him to break down the 800 he expects to hire as between professionals and nonprofessionals?

Dr. SILVERSTEIN. I will provide that.

(The information requested follows:)

Goddard Space Flight Center personnel

	Fiscal year 1960	Fiscal year 1961	Increase
Professional	593	885	292
Technical support	370	689	319
Administrative	251	426	175
Total	1,214	2,000	786

PROPOSED STAFFING FOR WALLOPS ISLAND STATION

Mr. THOMAS. What about your Wallops Island station?

We shall insert at this point in the record the chart which appears at page 13–25 of the justifications.

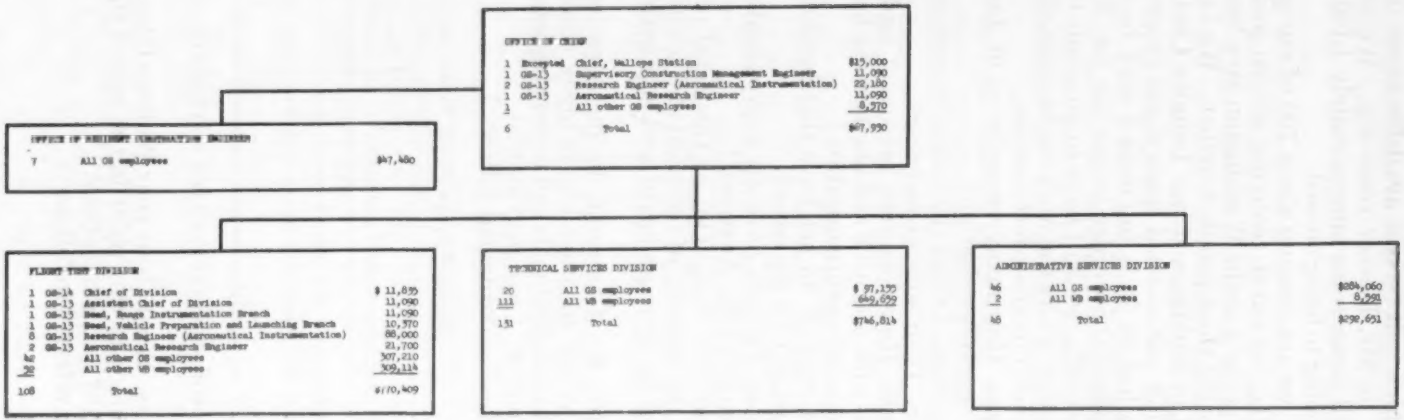
(The chart referred to follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Proposed personnel staffing chart

F.Y. 1961

WALLOPS STATION


OFFICE OF CHIEF
1 Excepted Chief, Wallops Station $15,000
1 GS-15 Supervisory Construction Management Engineer 11,090
2 GS-15 Research Engineer (Aeronautical Instrumentation) 22,180
1 GS-15 Aeronautical Research Engineer 11,090
3 All other GS employees 8,270
6 Total $67,930
OFFICE OF RESIDENT CONSTRUCTION ENGINEER
7 All GS employees $47,480
FLIGHT TEST DIVISION
1 GS-14 Chief of Division $ 11,835
1 GS-13 Assistant Chief of Division 11,090
1 GS-13 Head, Range Instrumentation Branch 11,090
1 GS-13 Head, Vehicle Preparation and Launching Branch 10,370
8 GS-13 Research Engineer (Aeronautical Instrumentation) 88,000
2 GS-13 Aeronautical Research Engineer 21,700
46 All other GS employees 307,210
28 All other WB employees 109,114
108 Total $670,409
TECHNICAL SERVICES DIVISION
20 All GS employees $ 97,135
111 All WB employees 669,679
131 Total $766,814
ADMINISTRATIVE SERVICES DIVISION
46 All GS employees $284,060
2 All WB employees 6,591
48 Total $290,651

Dr. SILVERSTEIN. This Wallops group has been in operation for quite some time.

Mr. THOMAS. I note you go from 225 people to 300 people.

Dr. SILVERSTEIN. Yes, sir; they are increasing. This is a group which has been active for a number of years. I think our initial activity at Wallops started back in 1945. They have been responsible for essentially developing a whole new technique for operations at high altitudes and at high speeds. We are using the Wallops station for a high percentage of our sounding rocket flights and also are planning that the SCOUT satellite vehicle will be fired from Wallops.

The station consists, of course, of small launching facilities and rather extensive tracking and data recovery facilities in the nature of antennas to recover telemetry data and to track the bodies that are being fired from Wallops out to distances that the range extends.

Mr. THOMAS. We already have the table on Huntsville in the record, but let it show at this point that it is page 13–26.

You took over in the last 30 or 40 days about 4,300 people from the Army and some supporting personnel, and to that you are adding new people for a new total of 5,500.

Is that a fair statement?

Mr. ULMER. That is a fair summary; yes, sir.

PROPOSED STAFFING FOR WESTERN OPERATIONS OFFICE

Mr. THOMAS. This Western Operations Office is really getting upstairs. I remember when you had two people there, Doctor.

Do you remember when you had two people there?

Dr. DRYDEN. Yes, sir. That was when the function was solely one of technical liaison.

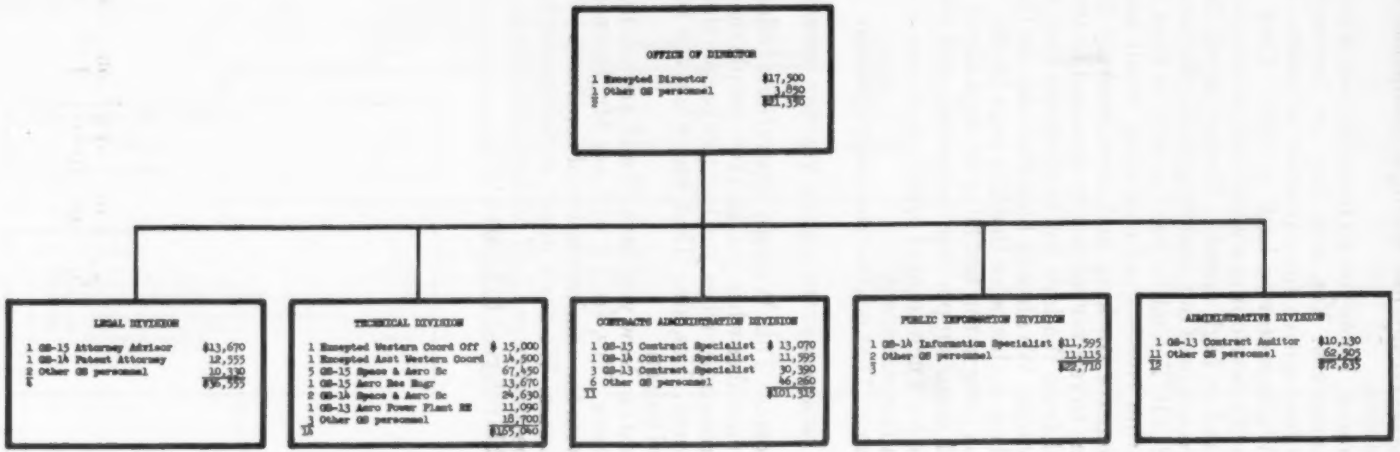
Mr. THOMAS. Now you have 32 and are asking for 46; is that right?

Dr. DRYDEN. Yes, sir. I will ask Mr. Horner to speak to this. It has to do with the administration of contracts.

Mr. THOMAS. We shall insert at this point in the record the table which appears at page 13–27 of the justifications.

(The table referred to follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
PROPOSED PERSONNEL STAFFING CHART
FISCAL YEAR 1961
WESTERN OPERATIONS OFFICE


OFFICE OF DIRECTOR
1 Excepted Director $17,500
1 Other GS personnel 1,890
2 $21,390
LEGAL DIVISION
1 GS-15 Attorney Advisor $13,670
1 GS-14 Patent Attorney 12,555
2 Other GS personnel 10,130
4 $36,355
TECHNICAL DIVISION
1 Excepted Western Coord Off $ 15,000
1 Excepted Asst Western Coord 14,500
5 GS-15 Space & Aero Sc 67,650
1 GS-15 Aero Res Engr 13,670
2 GS-14 Space & Aero Sc 24,630
1 GS-13 Aero Power Plant RE 11,090
3 Other GS personnel 18,700
15 $165,040
CONTRACTS ADMINISTRATION DIVISION
1 GS-15 Contract Specialist $ 13,070
1 GS-14 Contract Specialist 11,595
3 GS-13 Contract Specialist 30,390
6 Other GS personnel 46,260
11 $101,315
PUBLIC INFORMATION DIVISION
1 GS-14 Information Specialist $11,595
2 Other GS personnel 11,115
3 $22,710
ADMINISTRATIVE DIVISION
1 GS-13 Contract Auditor $10,130
11 Other GS personnel 62,505
12 $72,635

Mr. THOMAS. You have in your Administrative Division, 12; Public Information Division, 3; in your Contracts Administration Division, 11; in your Technical Division, 13; and in your Legal Division, 4. The Office of the Administrator has two.

What do all of these people do?

Mr. HORNER. The bulk of the work is in contract administration and contract auditing. The legal work in connection with our contract activity in the Western United States and in the technical liaison capacity in the Technical Division——

Mr. THOMAS. What functions do they serve and what installations do they serve?

Mr. HORNER. They administer the contracts we have with the California Institute of Technology which employs the Jet Propulsion Laboratory.

Mr. THOMAS. You have the Jet Propulsion Laboratory, Edwards and what else?

Mr. HORNER. They do not serve Edwards. Edwards has its own complement of personnel. The western office handles contract administration with industry in the California area.

Dr. DRYDEN. It is really a location of part of the headquarters staff on the west coast so they do not have to be running back and forth to Washington all the time.

Mr. THOMAS. What installations do they serve out there?

Mr. HORNER. They serve all of the centers and the headquarters in a technical liaison capacity.

Mr. THOMAS. Just what are their duties? Do they make contracts out there, or are they made at the central office?

Mr. HORNER. Ordinarily, the contracts are negotiated either by headquarters or by the centers, but they are then turned over to the Western Operations Office for contract administration. They, for example, authorize contract change on the basis of guidance which they receive from Washington of the field centers. They also perform technical liaison on a day-to-day basis for the individual development projects that we have in industry in the Los Angeles area. It saves a great deal of traveling from our other centers and from the headquarters to the Los Angeles location by virtue of having these people here, and we feel it is an economy.

Mr. THOMAS. You have 12 administrative people. What do they do? Do they take care of the 44 people? What is the nature of their duties?

Mr. HORNER. The Administrative Division that is shown here actually includes the auditing function which I mentioned earlier and the personnel services that are normal to that kind of an operation. They also handle many personnel services for visiting personnel who are there on business.

Mr. THOMAS. That west-coast operation is, perhaps, one of your biggest segments is it not, in that they handle the Cleveland business also?

Mr. HORNER. No, sir; just industrial contracts west of Denver.

Mr. ABBOTT. They do when Cleveland is buying something in that area, and they helped out very much just a few weeks ago on one matter on which we were working.

Mr. THOMAS. You have 400 or 500 people in the central office and you have 44 or 45 out there.

Mr. HORNER. I am sorry, sir. I may have misunderstood your question, Mr. Chairman. They do handle the business for Cleveland, Langley, and for all of the centers and for the headquarters that is carried on in the Los Angeles area. For example, we have contracts with Rocketdyne for the development of the F–1 engine.

NASA HEADQUARTERS OFFICE

Mr. THOMAS. What do these people do in the District of Columbia? You have 600 or 700 here. What do they do with regard to that business on the Pacific coast?

Mr. HORNER. The actual program implementation is not a function that we carry out within the headquarters. The coordination of the program and its interlacing with that of other governmental agencies is a responsibility of the people in Washington. Of course, our business with the Congress is a function of the headquarters. The Western Operations Office is more concerned with the actual implementation of the program and the actual day-to-day operations of the contractual program in the California area.

Mr. THOMAS. Can you put your finger on that table for the central office? How many are there? How many do you have in the District of Columbia doing this same work?

Mr. HORNER. Of course, we have the same types of work at almost all our locations. We have legal people, for example, at every center, at the headquarters office and at the Western Operations Office.

Mr. THOMAS. In addition to those in the District of Columbia?

Mr. HORNER. Yes, sir.

Mr. THOMAS. You have 40 in Financial Management, 29 in Personnel—you have 20 in your Management Analysis Division, 19 in your Audit Division, 44 in the Procurement and Supply Division, and 53 in the Administrative Services Division.

Dr. GLENNAN. Mr. Thomas, as compared with some of our sister agencies, our percentage of headquarters personnel is very low. I think, really, we ought to have you understand the situation.

In the March 7 Congressional Record, on page 4335, it is shown that the National Aeronautics and Space Administration had a percentage of 4.3 as of the end of fiscal 1960, and that the General Services Administration had 9.3.

Mr. THOMAS. What do you mean by "4.3"?

Dr. GLENNAN. 4.3 percent of our total staff in headquarters, as compared to our total personnel, sir. The Atomic Energy Commission had 25.3, the Federal Aviation Agency had 8.7, and the Small Business Administration had 23.6. Some of those are not directly comparable. But I make the point that in attempting to plan and manage a budgeted expenditure of the size we are talking about, and involving the number of diverse people and installations, I think for an agency which is exceeded in business by perhaps only a few corporations in the United States, we are doing it with too few people.

Mr. THOMAS. But you have that same setup at each one of your installations.

Dr. GLENNAN. At the local level to manage the 3,000 people at Langley, for instance, they have their administrative staff, but somebody has to pull this all together and someone has to answer questions here. Someone has to worry about our relationships with the other agencies and someone has to worry about our relationships with the public generally, and someone has to decide how we are going to plan this work and program and present it to you.

Dr. DRYDEN. And, to get some uniformity in policy between the field installations in all of these matters.

Mr. THOMAS. It takes that many, even though you have a duplication setup to do the same thing at each one of your installations?

Dr. DRYDEN. If you left it to themselves, you would have 10 different ways and 10 different policies.

Mr. HORNER. Of course, we do not have a duplicate setup at each one of these locations. It is quite different at the center level. Some areas of work are dominant and other areas are very minor in comparison to those that you find at headquarters.

Mr. THOMAS. Well, that is an assumption with which everyone may not agree.

Dr. DRYDEN. It is the same as the difference between the New York management of a big corporation and the management of each one of its field offices. The New York office fixes the general policy of the company and takes care of the other relationships and the local level runs the local business in accordance with the central policy.

Mr. THOMAS. Why do you need 650 people in the District of Columbia to manage your half-dozen installations when they are carrying out your orders? That is what I do not see.

Dr. DRYDEN. The variety of jobs which have to be done at headquarters to pull together and into a single program the activities of 16,000 people is very great. They range all the way from——

Mr. THOMAS. You are not doing it in the day-to-day work at the central office. The people in the field are doing that and they are managing their own people.

Dr. DRYDEN. It is a different kind of day-to-day work, with the Department of Defense, with AEC, with Congress and other agencies of Government as well as with industry representatives. We find something to do every day, I can assure you.

Dr. GLENNAN. Every day, including Sunday.

Dr. DRYDEN. There is a new crisis every day.

PROPOSED STAFFING FOR ATLANTIC MISSILE RANGE OPERATIONS OFFICE

Mr. THOMAS. Now, we come to the Atlantic Missile Range Operations Office. This is located down at Cape Canaveral, is it not?

Dr. GLENNAN. Yes, sir.

Mr. THOMAS. How many people do you have there?

Mr. ULMER. We currently have 12 people there, Mr. Thomas.

Mr. THOMAS. Is this the one where your AMRO office is located?

Mr. ULMER. Yes, sir; the Atlantic Missile Range Operations Office.

Mr. THOMAS. You set it up for 26. How many do you have there now?

Mr. ULMER. We have 12 on duty now, sir, out of an authorized strength of 20.

Mr. THOMAS. There are 23 on this chart. Did I overlook any of them? The ones at the top makes 26?

Mr. ULMER. Yes. We are requesting a total of 26 for 1961.

Mr. JONAS. Will you yield at that point, Mr. Chairman?

Mr. THOMAS. Yes.

Mr. JONAS. Is this rather more of a liaison office? They do not do any actual planning or research or programing, do they?

General OSTRANDER. It is primarily a liaison office. They make the necessary arrangements with the range to provide us the services we need for launching our vehicles.

Mr. THOMAS. You had 12 people when I was down there and you had, apparently, a Director who was all over the lot and who apparently knows his business and gets around pretty well. Frankly, I did not see how you could use 12 people down there, much less 26. Your work is planned up here and your contractors carry out your shots down there. You work hand in glove with the Air Force.

What is the use of building this up now?

General OSTRANDER. Our firing rate will be building up at a much greater rate.

Mr. THOMAS. But these people are not going to do the firing.

General OSTRANDER. Yes, sir; but they have to place upon the range our requirements for tracking and for data and for facilities and so on in order that they know what we need to get out of our shots.

Dr. GLENNAN. It is a technical and administrative housekeeping group.

Mr. THOMAS. I note that you have two GS–14's, three GS–13's, one GS–18, one GS–15, and so on.

TRAVEL

Your travel goes up at the headquarters from $922,700 to $1,000,000.

Why the increase in so much travel at the headquarters? Your entire travel bill is what? Is it $5 million this year?

Mr. ULMER. It is $5,849,000 for 1961, Mr. Thomas, and it is $2,866,400 for 1960.

Mr. THOMAS. It is $2,866,400 for 1960 and goes up to $5,849,000 in 1961.

Your headquarters travel jumps from $922,700 to $1,100,000.

Mr. ULMER. Mr. Thomas, the main reason for that increase is the additional activity programed in the space flight programs and operations which Dr. Silverstein discussed earlier and which General Ostrander discussed, particularly in connection with the tracking ranges coming into operation and the increased firings involved in the MERCURY program.

You recall last year, Mr. Thomas, we asked you to go along on faith on our travel estimate until we had a year of experience under our belt. I think our estimate last year has proved to be fairly reasonable. If you prorated our current $2.8 million allotment figure on a straight line month-by-month basis, we would come out with a January 31 allotment somewhere in the neighborhood of $1.7 million. We had obligated on that date about $1.5 million. We are about $200,000 under what you might call a straight-line basis.

Mr. THOMAS. Who is going to do the traveling at the national headquarters? How many people are in a travel status?

Mr. ULMER. Well, there will be many people in a travel status but, mainly, the technical people reporting to Dr. Silverstein, General Ostrander, and Mr. Abbott in directing and coordinating the programs at the various NASA Centers. You will notice a breakdown down at the bottom of the $5.8 million, on page 14; $1.1 million is for our program coordination within our own activities and $1,440,000 is for coordination with other Government agencies. The tracking item shows an increase of $943,000 to $1,950,000. This is the item we spoke of earlier which shows a substantial increase.

It should be pointed out also that included in the $5,849,000 request is the entire travel requirement for the Huntsville activity which comes to us as a full year requirement for the first time. This appears as a zero in the 1960 column.

Mr. THOMAS. Where do the people at Huntsville travel to and from?

General OSTRANDER. They will be traveling very largely to the Atlantic missile range.

Mr. THOMAS. They go over to Florida, do they not?

General OSTRANDER. Yes, sir.

Dr. GLENNAN. As well as to Rocketdyne and Convair.

General OSTRANDER. They will be supervising our contracts on the west coast on the AGENA–B and on the CENTAUR, and they will be supervising contracts with Pratt & Whitney in Florida and they will be working with the Atomic Energy people at Los Alamos and in Washington as well as traveling to Goddard and JPL and traveling also to our research stations at Ames, Lewis, and Langley in connection with all our supporting research.

Mr. THOMAS. You have traveled to meetings of technical committees and working panels in the amount of $360,000.

Are these outside people or are they your own people?

Mr. ULMER. They are both, sir.

Mr. THOMAS. You have listed "Meetings of technical societies, $189,500." Is that for travel of your people to these society meetings?

Mr. ULMER. Entirely travel of our people to these outside technical meetings.

Mr. THOMAS. You also have travel to initial duty stations in the amount of $250,300, do you not?

Mr. ULMER. Yes, sir.

Mr. THOMAS. How is your travel money lasting in the first 6 months of this year?

Mr. ULMER. I have a figure here, Mr. Thomas, as of the end of January. We have obligated about $1.5 million compared to an allotment of $1,670,000. We are within the ball park of the rough estimate we gave you last year.

Mr. THOMAS. Well, on that basis, you will have a carryover of $200,000 or $300,000?

Mr. ULMER. I suspect it will be somewhere around $100,000 or $150,000, but I think that is a fairly good estimate on a $2.8 million item in this kind of a program.

Mr. THOMAS. Your "Transportation of things" runs into money also, and this does not include drayage and freight. This is only the movement of your household goods. Transportation of supplies and equipment, and drayage and other local transportation is charged to other contractual services under the R. & D. appropriation?

Mr. ULMER. Yes, sir.

Mr. THOMAS. With reference to your transportation of household goods, how do you arrive at this figure of $442,000 as against $191,000?

Mr. ULMER. Mr. Chairman, as you know, all Federal agencies have authority of law to pay for shipment of household goods to the first duty station. This is relatively new in Government and this is the major reason we see an increase. Another reason for the increase is the transportation of some of the Goddard people that Dr. Silverstein spoke about to the Goddard Center as its buildings are finished. Some of these people are now located at the Langley Center.

Mr. THOMAS. There are 400 of them there?

Mr. ULMER. No, sir, about 600.

Mr. THOMAS. You will only move them a distance of 150 miles.

Mr. ULMER. Yes, sir.

Mr. THOMAS. Is it 150 miles, or what?

Mr. ULMER. Yes, sir; about 150 miles. Included here also——

Mr. THOMAS. And, you have in here about $250,000 for it.

Mr. ULMER. We are also proposing to add somewhere in the neighborhood of 800 additional people; for some of these, we will have to pay the transportation of their household goods to the initial duty station. Our past experience has indicated that this type of cost runs between $400 and $500 per person.

Mr. THOMAS. I believe the law gives you that authority; which makes sense.

Mr. ULMER. Yes, sir.

Mr. THOMAS. Since these people have been on duty down there for a long time, I doubt if they come within this law.

Mr. ULMER. They do, sir; if we order a change in duty station.

Mr. THOMAS. It might be bad news to them.

Mr. ULMER. If the transfer is required in the interest of the Government, we are authorized to pay their transportation cost. Where it is for the convenience of the employee, we do not.

Mr. THOMAS. Wherever they are transferred at your orders, they are always subject to it?

Mr. ULMER. Yes, sir.

Mr. THOMAS. The first duty and transfers too, as well, as I remember?

Mr. ULMER. Yes, sir.

Mr. THOMAS. You are not going to spend $250,000 to transfer 400 to 500 people 150 miles?

What will happen to the rest of it?

Mr. ULMER. The rest of it is involved in the initial duty transportation cost of some of the 800 new employees we are requesting, plus similar costs for some turnover replacements.

Mr. THOMAS. Is my friend, the doctor over there, showing any turnover? He only had 37 vacancies at one of his laboratories and 15 at another. They like to work with him.

Mr. ULMER. The turnover is about 11.5 percent a year, on an average.

COMMUNICATION SERVICES

Mr. THOMAS. Your communication services almost double. They go from $883,600 to $1,314,000.

At this point in the record we shall insert page 17 of the justifications.

(The page referred to follows:)

04 Communication services

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$205,531	$432,000	$535,000
Langley Center	51,009	70,000	82,000
Ames Center	32,573	35,000	42,000
Lewis Center	71,039	75,000	94,000
Flight Center	62,313	15,000	20,000
Goddard Center	17,377	203,000	244,000
Wallops Station	5,842	33,600	40,000
NASA Huntsville			229,000
Western office	4,361	10,000	12,000
AMRO office	1,776	10,000	12,000
PMRO office			4,000
Wright office	48		
Total, all locations	451,869	883,600	1,314,000
Analysis by types of service:			
Local telephone and exchange service	125,225	195,770	249,000
Long-distance toll charges	149,181	430,130	627,000
Telegraph service	37,072	137,625	257,900
Postage	78	75	100
Penalty mail	80,000	120,000	180,000
Leased lines	60,313	(1)	(1)
Total, all types of communication services	451,869	883,600	1,314,000

[1] Funded under "Research and development."

Mr. THOMAS. Your local telephone and exchange service goes from $195,770 to $249,000. Your long-distance toll charges go from $430,130 in 1960 to an estimated $627,000 in 1961.

Mr. ULMER. Yes, sir.

Mr. THOMAS. Your telegraph service goes from $137,625 to $257,900.

How did you arrive at this figure of $257,900?

Mr. ULMER. This, again, is a summary of estimates made at each of the centers, Mr. Thomas. The breakdown at the top of the page indicates the change between——

Mr. THOMAS. The only new item you have is $229,000 in here for Huntsville.

What did they spend at Huntsville under the Army last year?

Mr. ULMER. I do not have that specific figure but, generally, the Huntsville figures are derived from the Army experience of the preceding year.

Mr. THOMAS. You mean the $229,000 is the exact amount that the Army spent last year?

Mr. ULMER. No. I do not say it is the exact amount. However, these figures are derived from their experience. I believe it would be quite close.

Mr. THOMAS. Off the record.

(Discussion off the record.)

RENTS AND UTILITY SERVICES

Mr. THOMAS. The next item covers your "Rents and utility services" and at this point in the record we shall insert pages 18 and 19 of the justifications.

(The pages referred to follow:)

05 Rents and utility services

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$16,559	$103,000	$30,000
Langley Center	2,709,143	2,971,000	4,407,000
Ames Center	2,651,526	2,828,000	3,565,000
Lewis Center	2,608,431	3,044,800	3,693,000
Flight Center	81,565	93,000	179,000
Goddard Center	3,774	338,000	5,463,000
Wallops Station	50,101	125,000	409,000
NASA Huntsville			6,050,000
Western office	10,047	46,000	46,000
Total, all locations	8,131,146	9,548,800	23,842,000
Analysis by types of rents and services: Electric power:			
Langley Center	1,880,782	2,032,000	2,592,000
Ames Center	2,238,271	2,268,000	2,612,000
Lewis Center	2,014,946	2,073,800	2,405,000
Flight Center	7,152	8,000	14,000
Goddard Center		8,000	75,000
Wallops Station	50,075	105,000	145,000
NASA Huntsville			[1]
Total, electric power	6,191,226	6,494,800	7,843,000
Water:			
Ames Center	36,224	45,000	60,000
Lewis Center	42,276	51,050	60,000
Flight Center	204	250	250
Goddard Center		2,000	25,000
Total, water	78,704	98,250	145,250
Gas:			
Ames Center	36,698	44,000	64,000
Lewis Center	274,284	317,000	375,000
Flight Center	7,750	8,750	14,750
Total, gas	318,732	369,750	453,750
Miscellaneous utility services: Ames Center, total, miscellaneous utility services	931	1,000	1,000
Data-reduction equipment rental:			
NASA Headquarters	12,071		
Langley Center	825,188	936,000	1,812,000
Ames Center	338,753	469,000	826,000
Lewis Center	275,987	600,000	850,000
Flight Center	66,210	75,500	149,500
Goddard Center	3,774	328,000	5,363,000
Wallops Station		19,900	263,900
NASA Huntsville			6,050,000
Total, data-reduction equipment rental	1,521,983	2,428,400	15,314,400

[1] Electric power and other utilities for NASA Huntsville will be provided by contract with the Department of the Army: funding included under object 07, support of NASA plant, in the "Research and development" appropriation.

Mr. THOMAS. Your big item here is your power bill, is it not?

Mr. ULMER. It used to be, Mr. Thomas. The rental of data reduction equipment is the big item now. The power item used to be the large item.

Mr. THOMAS. At your Langley Center the figure for 1960 is $2,971,000, and the estimate for 1961 is $4,407,000. What is that for? That is power, is it not?

Mr. ULMER. The power goes from $2,032,000 to $2,592,000 and the data reduction equipment rental goes from $936,000 to $1,812,000 at Langley. That information appears on page 19, sir. Page 18 gives the electric power breakdown by each activity and page 19 gives the equipment rental breakdown.

Mr. THOMAS. Langley goes from $2,032,000 to $2,592,000. This is for your tunnels?

Mr. ABBOTT. Yes, sir; largely.

Mr. THOMAS. Ames goes from $2,268,000 to $2,612,000?

Mr. ULMER. Yes, sir.

Mr. THOMAS. Lewis goes from $2,073,800 to $2,405,000?

Mr. ABBOTT. Yes, sir.

Mr. THOMAS. Why all this increase in power? Have you not been running them?

Mr. ABBOTT. Well, in some of these cases we have not. We have in some cases had to use less power; we have also had some tunnel breakdowns.

Mr. THOMAS. You mean you could not buy it and it was not available to you? You never have been short any money to buy anything with.

Mr. ABBOTT. This varies from center to center. The new things we are getting into are forcing us to run our equipment nearer to the end of their capabilities.

Mr. THOMAS. You are still testing airplanes?

Mr. ABBOTT. Largely not, sir, as the chart which was shown before indicated, but as we get out into the very high-speed regimes, we usually have to operate our tunnels at a higher power level.

Mr. THOMAS. Is the current rate going up any? I imagine if you looked into it you are paying a 5-percent increase in current rate, and that would account for your increased cost rather than the increased activity.

Mr. ULMER. Mr. Thomas, may I call your attention to the chart which appears on page 21?

Mr. THOMAS. I looked at it but I could not understand it.

Mr. ULMER. There were two facilities which were shut down during part of 1960 which will be in full operation during 1961.

Mr. THOMAS. What about your increase in power rate cost? It went up in the District of Columbia. You have this installation down here served by the same company which the District of Columbia is served by and it went up 5 or 7 percent.

Mr. ULMER. Actually, the unit cost is down in 1961, Mr. Thomas, compared to 1960.

Mr. THOMAS. What was it this year? Was there not an increase at Langley?

Mr. ULMER. This year the average energy cost is higher than it was last year—7.12 to 7.08 average cost per megawatt-hour.

Mr. THOMAS. Is that an increase or decrease?

Mr. ULMER. It is an increase in 1960 over 1959.

Mr. THOMAS. What was that increase? Was it about 5 percent?

Dr. DRYDEN. About one-half of 1 percent.

Mr. THOMAS. And what was the unit cost?

Dr. DRYDEN. 7.08 to 7.12 down to 7.02 next year.

Mr. THOMAS. I think the General Services Administration generally paid in this area about 5 percent. Of course, you buy tremendous quantities.

Mr. ULMER. Our overall rate, energy plus demand costs, fluctuates with the type and the level of demand we require.

Mr. THOMAS. And, of course, you buy all peak power do you not?

Mr. ULMER. Both on-peak and off-peak.

Mr. THOMAS. And, so, your negotiators did not do such a good job after all, did they?

Mr. HORNER. The overall cost has gone down every year.

Mr. THOMAS. You mean the unit overall cost?

Mr. HORNER. The unit overall cost. The energy cost has gone up, but the unit demand cost has gone down enough to take care of it. In the book here at page 23, for example, is Langley.

Mr. THOMAS. When the print gets that fine, I refuse to read it. My eyes do not work that well.

Dr. DRYDEN. The average overall cost per megawatt hour purchased was 11.25 in 1959, 10.92 in 1960, and 10.85 in 1961. At Ames it was 9.09, 8.98, and 8.32.

Mr. THOMAS. You have a Bonneville rate there; do you not?

Dr. DRYDEN. The cheapest rate is at Lewis. We did go up from 8.00 to 8.36 in 1960 and down to 8.19 in 1961.

Mr. THOMAS. I suppose your cheapest rate will be down at Huntsville?

Dr. DRYDEN. I do not know. The amount of power is much smaller there.

Mr. THOMAS. That is the TVA area. You are in the TVA area. So, you ought to have a cheaper rate there than at any of the others.

Mr. RHODES. Do you not buy power at Ames from the Central Valley project?

Dr. DRYDEN. There is a mixture of power both from Bonneville up to a certain point, and beyond that from the Pacific Gas & Electric Co.

Mr. RHODES. P.G. & E. and Central Valley?

Mr. ULMER. The chart on page 26 breaks out the amount that we take both from the Bureau of Reclamation and from Pacific Gas & Electric.

Mr. THOMAS. Let us see what the other item costs are in there. What page is that on? Is it on page 29 or page 30?

Dr. DRYDEN. At the Ames Laboratory, sir——

Mr. THOMAS. No; you had a table setting out the others.

Mr. HORNER. That is page 19; is it not?

Mr. THOMAS. I believe it is page 32. You have your gas here and your miscellaneous services. Your next largest item is your rental equipment. This is beginning to run into money.

Your big item is at Huntsville this year?

Mr. ULMER. Yes, sir.

Mr. THOMAS. And, next, it is Goddard?

Mr. ULMER. Yes, sir.

Mr. THOMAS. I thought your big data reduction center was going to be at Goddard. Why is Huntsville larger than Goddard?

General OSTRANDER. Huntsville has, as a matter of fact, the largest single computing facility, I believe, in the country.

Mr. HORNER. The Huntsville computed capability is used primarily for design to support the industrial manufacturing process there, whereas the Goddard data facility is for data reduction and data handling generally.

OTHER CONTRACTUAL SERVICES

Mr. THOMAS. What about your other contractual services here?

Mr. ULMER. Mr. Chairman, these cover the types of other contractual services that can be estimated on an annual basis.

Mr. THOMAS. Your research contracts are not carried here.

Mr. ULMER. They are carried under the R. & D. appropriation.

Mr. THOMAS. Where is your new health program?

Mr. ULMER. That is on page 33, Mr. Chairman, in the amount of $900,300.

Mr. THOMAS. You have one new item and that is in the amount of $900,300?

Mr. ULMER. Yes, sir.

Mr. THOMAS. Your life insurance is in the amount of $392,000 and is an old program; is it not?

Mr. ULMER. Yes, sir.

Mr. THOMAS. Why have your security investigations jumped this much, from $500,000 to $1,248,000, or 2½ times?

You are only going to employ 800 new people. Why does it jump 2½ times?

Mr. ULMER. We also have the Huntsville operation.

Mr. THOMAS. Why does it jump up 2½ times?

Mr. ULMER. We will have the responsibility for the security investigations for the Huntsville staff for the first time, Mr. Thomas; the estimate also provides for an expanded industrial security program.

Mr. THOMAS. They are on the payroll already. So you do not have to investigate them again?

Mr. ULMER. There are approximately 3,000 employees at this installation who have previously received security clearances which do not meet NASA clearance standards as established under the Space Act. These employees will be subjected to security investigations by the NASA. It is proposed to complete this program by 1963. And we do have the normal turnover problem throughout the Agency, plus the 800 additional people we propose to hire in 1961.

Mr. THOMAS. Certainly that should not cost $1 million to investigate.

Mr. JONAS. Is this done by the FBI or by the Civil Service?

Dr. GLENNAN. Both by the FBI and Civil Service, but mostly Civil Service.

Mr. JONAS. They cost around $78 each; is that right?

Mr. ULMER. It is around $400 apiece.

Mr. JONAS. It is $400 a person?

Mr. ULMER. Mr. Thomas, may we supply some additional information on the security investigations, giving you the detailed backup? I am sorry I do not have it with me, other than in those general terms.

Mr. THOMAS. As well as I remember, your average investigation in the civil service jumped this year from $70 to $80.

Mr. ULMER. It is around $400.

Mr. TOHMAS. If you go to the FBI you get up in the $400 class.

Mr. ULMER. These are civil service costs, Mr. Chairman. I think they run $300 and $400.

Mr. THOMAS. Did they go up that high? I remember there was an increase of about $12 or $15 a case.

Mr. ULMER. This is for full field clearances. This is not the agency check which is a relatively simple thing.

Mr. THOMAS. Yes; but your people do not have that.

Mr. ULMER. Most of our people are full field investigated.

Mr. THOMAS. It runs up around $300 to $400 for a full field investigation?

Mr. ULMER. That is what we are paying, sir, because our people have to have full field clearances.

Mr. THOMAS. It jumped from $370 to $380 for the full field investigations.

SUPPLIES, MATERIALS, AND EQUIPMENT

Mr. JONAS. All of your supplies, materials, and equipment you fund under "Research and development"?

Mr. ULMER. Yes, sir; except that a capital equipment item whose estimated cost exceeds $250,000 is funded under the C. & E. appropriation.

GRANTS, SUBSIDIES, AND CONTRIBUTIONS

Mr. JONAS. I notice that your "Grants, subsidies, and contributions" go up from $4,566,300 to $7,618,500.

Mr. ULMER. Mr. Jonas, as you will note at the bottom of that page, it is all based on a 6½ percent calculation of certain personnel costs. So, it is a figure keyed directly with the "01 Personal services" item.

Mr. JONAS. The principal increase is at Huntsville?

Mr. ULMER. That is right, sir.

Mr. JONAS. At this point in the record we shall insert page 36 of the justifications.

(The page referred to follows:)

11 Grants, subsidies, and contributions

	Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
Analysis by location:			
NASA Headquarters	$152,505	$321,400	$380,000
Langley Center	1,420,251	1,416,150	1,441,000
Ames Center	644,968	665,850	677,000
Lewis Center	1,236,204	1,271,200	1,280,000
Flight Center	129,084	163,200	188,000
Goddard Center	91,719	607,520	911,000
Wallops Station	40,068	81,000	114,000
NASA Huntsville		14,000	2,585,000
Western Office	3,122	15,480	25,300
AMRO Office	954	10,500	14,500
PMRO Office			2,700
Wright Office	933		
Total, all locations	3,719,808	4,566,300	7,618,500
Calculation of Government contributions to retirement fund:			
Total, all personal services			125,425,000
Personal services not subject to retirement deductions:			
Intermittent employment		250,000	
Overtime and holiday pay		5,887,000	
Nightwork differential applicable to classified employees		100,000	
Other allowances		67,000	
Reimbursements for details from other Government agencies		450,000	
Terminal leave payments		267,000	
Salaries subject to deductions for social security		1,196,000	−8,217,000
Total, personal services subject to retirement deductions			117,208,000
Total, Government contributions computed at 6½ percent			7,618,500

PERSONNEL TURNOVER RATIO

Mr. JONAS. What is your general turnover in your personnel? What will it average throughout the Agency?

Dr. GLENNAN. Seven percent, I think it is.

Mr. ULMER. About 7 for scientific personnel; 11.5 average for all personnel.

Mr. JONAS. At all of your agencies and all of your laboratories the average scientific turnover is about 7 percent?

Mr. ULMER. Yes, sir; that is an overall NASA average.

Mr. JONAS. In what category would that be? Would it be across the board?

Mr. ULMER. That is the overall average.

Mr. JONAS. What about your scientists? Are you having any heavier turnover in that category than in your clerical personnel?

Mr. ULMER. About 7 percent for the scientific people; the clerical turnover is much heavier.

Mr. JONAS. Do you have any recruitment problem or any trouble replacing your scientific personnel?

Dr. GLENNAN. I will ask Dr. Silverstein to answer that question, sir.

Dr. SILVERSTEIN. The situation this year has been quite good. We have in the past had difficulty.

Dr. GLENNAN. We offered jobs to 55 Ph. D.'s last year and we got 3. At the Ph. D. level we seem to be unable to attract people. We are about $3,000 under the market at the Ph. D. level.

Mr. JONAS. When you refer to the Ph. D. level, you include scientists?

Dr. GLENNAN. Yes, sir, these are scientists and engineers principally.

Mr. JONAS. I should think you would have an intangible asset which other agencies do not have, and that is the glamorous aspect?

Dr. GLENNAN. Yes, sir.

Dr. SILVERSTEIN. That has helped us this year.

Mr. THOMAS. That brings them in.

Dr. SILVERSTEIN. The salaries in industry this year on the average have gone up over last year. We are not competitive at the lowest level of employment.

Dr. GLENNAN. We are $1,000 under the market for the bachelor degree man this year.

REFUNDS, AWARDS, AND INDEMNITIES

Mr. JONAS. With reference to the analysis by types of awards and claims, I notice that your tort claims are pretty high: $129,000 in 1960 and your estimate is $140,000 for 1961.

With reference to the incentive awards, are they handled at the installations or out of Washington?

Mr. ULMER. These are handled at the installations, Mr. Jonas.

Quite frankly, I think the tort claims are relatively low for this size of an operation. They are made up of dozens of small claims.

Mr. JONAS. Personal injuries?

Mr. ULMER. Yes, but mostly for automobile and property damage and that type of thing.

ESTIMATES OF APPROPRIATION

Mr. THOMAS. We shall insert at this point in the record the coverall sheet which is page 39 of the justifications.

(The page referred to follows:)

Estimates of appropriations, salaries and expenses, fiscal year 1961

		Fiscal year 1959 obligated	Fiscal year 1960 estimated	Fiscal year 1961 estimated
01	Personal services:			
	Number of permanent positions (end of year)	9,286	10,086	16,373
	Annual cost of permanent positions (end of year)	$65,142,007	$73,254,506	$120,246,731
	Deduct lapses	6,294,304	3,328,066	2,389,731
	Net cost of permanent positions	[1] 58,847,703	69,926,440	117,857,000
	Intermittent employment	[1] 4,016	67,900	250,000
	Regular pay above 52-week base	[1] 246,121	558,710	463,000
	Overtime and nightwork differential	[1] 776,388	1,530,300	9,538,000
	Other allowances	[2] 15,574	33,000	67,000
	Reimbursable details	27,311	164,450	450,000
	Total personal services	[1] 59,917,113	72,280,800	128,625,000
02	Travel	[1] 1,285,911	2,866,400	5,849,000
03	Transportation of things:			
	Household goods	[1] 103,991	191,000	442,000
	All other	[1] 279,887	[2] 1,485,000	[2] 3,993,000
04	Communication services:			
	Leased lines	60,313	[2] 156,500	[2] 336,000
	All other	391,556	833,600	1,314,000
05	Rents and utility services:			
	Electric power	6,191,226	6,494,800	7,843,000
	Other utilities	398,367	469,000	600,000
	Rentals	1,541,553	2,585,000	15,399,000
06	Printing and reproduction	160,466	203,000	363,000
07	Other contractual services:			
	Research contracts	816,510		
	Repairs and alterations	[1] 1,221,710	[2] 2,012,100	[2] 5,060,000
	Miscellaneous services	[1] 947,020	[2] 1,522,400	[2] 7,403,000
	Services by other Government agencies	[1] 20,421,095	[2] 2,556,000	[2] 5,079,000
	Security investigations	178,595	500,000	1,248,000
	Federal life insurance	[1] 185,440	214,000	392,200
	Federal health program			900,300
08	Supplies and materials	[1] 6,927,053	[2] 8,636,000	[2] 17,607,000
09	Equipment	[1] 3,632,845	[2] 6,316,000	[2] 11,867,000
11	Grants, subsidies, and contributions	[1] 3,785,722	4,566,300	7,618,500
13	Refunds, awards, and indminities	3,202	134,000	147,000
15	Taxes and assessments	[1] 10,868	12,100	19,000
	Total	108,460,443	114,084,000	222,105,000
	Partially or fully funded under "Research and Development"	−22,472,147	−22,684,000	−51,345,000
	Unobligated balance	298,004		
	Total allotment	86,286,300	91,400,000	170,760,000

[1] Partially funded under "Research and development."
[2] Fully funded under "Research and development."

Mr. THOMAS. That winds up the "Salaries and expenses" item, I believe.

Dr. GLENNAN. Yes, sir.

Mr. THOMAS. The succeeding pages are breakdowns by installations?

Dr. GLENNAN. Yes, sir.

Construction and Equipment

Program and financing

	Costs to this appropriation					Analysis of 1961 financing			Appropriation required to complete
	Total estimate	To June 30, 1958	1959 actual	1960 estimate	1961 estimate	Deduct selected resources and unobligated balance, start of year	Add selected resources and unobligated balance, end of year	Appropriation required for 1961	
Program by activities:									
1. Aeronautical and space research facilities:									
(a) Langley Research Center	$67,904,134	$21,377,200	$10,600,207	$9,291,727	$5,500,000	$14,678,000	$21,135,000	$11,957,000	
(b) Ames Research Center	25,465,548	2,688,412	5,259,895	4,669,241	6,000,000	11,868,000	6,848,000	980,000	
(c) Lewis Research Center	62,968,189	19,642,728	10,038,970	8,636,491	5,500,000	15,550,000	19,150,000	9,100,000	
(d) Flight Research Center	1,850,000			350,000	1,500,000	1,500,000			
2. Space flight development and operations facilities:									
(a) Goddard Space Flight Center	27,437,000		166,832	4,000,168	10,000,000	13,770,000	13,270,000	9,500,000	
(b) Wallops Station	21,753,000	141,764	1,232,623	4,878,613	6,000,000	11,500,000	9,500,000	4,000,000	
(c) Jet Propulsion Laboratory	12,755,000			1,955,000	3,000,000	5,800,000	7,800,000	5,000,000	
(d) NASA Huntsville facility	28,392,000		1,472,899	169,101	3,000,000		23,750,000	26,750,000	
(e) Atlantic Missile Range	36,340,000		1,154,803	7,235,197	4,700,000	200,000	23,250,000	27,750,000	
(f) Pacific Missile Range	760,000			460,000	300,000	300,000			
(g) Various locations:									
Tracking facilities	69,520,000		271	16,424,729	32,500,000	25,345,000	20,595,000	27,750,000	
Propulsion development facilities	9,950,000			3,450,000	3,000,000	6,500,000	3,500,000		
3. Reserves	69,773					69,773	69,773		
Total program costs	365,164,644	43,850,104	29,926,500	61,520,267	81,000,000	107,080,773	148,867,773	122,787,000	
4. Relation of costs to obligations: Obligations incurred for costs of other years, net			10,719,300	43,512,798	50,287,000				
Total program (obligations)			40,645,800	105,033,065	131,287,000				
Financing:									
Comparative transfers from (−) Department of Defense			−2,627,702	−6,864,298					
Unobligated balance brought forward			−29,431,638	−39,413,540	−30,069,773				
Unobligated balance carried forward			39,413,540	30,069,773	21,569,773				
New obligational authority			48,000,000	88,825,000	122,787,000				
New obligational authority:									
Appropriation			48,000,000	73,825,000	122,787,000				
Transferred from "Research and development" (Public Law 86-213)				15,000,000					
Appropriation (adjusted)			48,000,000	88,825,000	122,787,000				

Object classification

		1959 actual	1960 estimate	1961 estimate
09	Equipment	$5,000,000	$25,000,000	$25,000,000
10	Lands and structures	35,645,800	79,440,445	106,287,000
	Total, National Aeronautics and Space Administration	40,645,800	104,440,445	131,287,000
	ALLOCATION ACCOUNTS			
07	Other contractual services		11,620	
10	Lands and structures		581,000	
	Total, allocation accounts		592,620	
	Total obligations	40,645,800	105,033,065	131,287,000

Mr. THOMAS. Now, gentlemen, let us take a look at the "Construction and equipment" item in the amount of $122,787,000.

I have here a notation to see page 308 of the justifications. Where is page 307? I cannot find it in my book.

Mr. ULMER. You may have mine, Mr. Chairman.

Mr. THOMAS. What did you have for this item last year? Was that figure $88,825,000?

Mr. ULMER. That is correct, sir. That includes an adjustment of $15 million of money transferred from the "Research and development" appropriation with the authority that you gave us last year in the appropriation bill.

Mr. THOMAS. You cover it very well on pages 302 and 303 of the justifications. You break it down there.

JUSTIFICATION OF THE ESTIMATES

We shall insert at this point in the record pages 302, 303, and 304 of the justifications.

(The pages referred to follow:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION CONSTRUCTION AND EQUIPMENT

PROGRAM AND PERFORMANCE

This appropriation provides for the modernization of existing facilities, the construction of new facilities including design by contract, and the purchase of major items of equipment. The costs shown in 1961 include those related to projects authorized in prior years. The principal project proposed for construction in 1961 are as follows:

1. *Aeronautical and space research facilities.*—(*a*) Langley Research Center: Proposed projects include an aerothermal dynamics facility to simulate the environment of vehicles in the hypersonic speed ranges and a laboratory to study the dynamics of objects in various density, temperature, acceleration, and vibration environments.

(*b*) Ames Research Center: Additional equipment for a centrifuge to test the effects of high acceleration in space vehicle equipment will be procured in 1961.

(*c*) Lewis Research Center: It is proposed to construct a basic materials research laboratory and a laboratory for research on energy conversion and power generation processes and equipment.

(*d*) Flight Research Center: Projects funded under the 1960 appropriation will be completed in 1961. No new projects are proposed.

2. *Space flight development and operations facilities.*—(*a*) Goddard Space Flight Center: The proposed contruction in 1961 consists of a payload test facility, a satellite systems laboratory, and utility installations.

(*b*) Wallops Station: Improvements to be added in 1961 include a system to determine the precise trajectory of launched vehicles, an operations computing center, and the modernization of certain existing support equipment.

(*c*) Jet Propulsion Laboratory: The 1961 program includes the acquisition of approximately 3 acres of land, the modernization of laboratory facilities, a solid propellent facility, a liquid propellent test cell, an antenna range, and the acquisition of approximately 3 acres of land.

(*d*) NASA Huntsville facility: It is proposed to construct in 1961 a SATURN static test facility, a central laboratory and office facility, a dynamic test facility, an addition to a fabrication laboratory, an extension to an assembly building, a pressure test cell, and additions to the engineering and guidance and control buildings, all to enable the Huntsville facility to carry forward the SATURN project and its work on other space flight development projects.

(*e*) Atlantic Missile Range: Completion of the SATURN launching complex and an addition to the engineering and laboratory building are proposed in 1961. In addition, a supplemental appropriation is anticipated for 1960 and is shown under "Proposed for later transmission."

(*f*) Pacific Missile Range: Launching facilities funded under the 1960 appropriation will be completed in 1961. No new projects are proposed in 1961.

(*g*) Various locations:

Tracking facilities: The 1961 program includes additional electronic and optical equipment; control and data processing equipment; and accessory equipment, shelters, and utilities. These items are required to improve the capabilities of the minitrack satellite tracking network and the net for tracking deep-space probes and to complete the special tracking stations for the MERCURY-manned space flights. In addition, a supplemental appropriation is anticipated for 1960 for the MERCURY net and is shown under "Proposed for later transmission."

Propulsion development facilities: Projects initiated in 1959 and 1960 will be completed in 1961. No new projects are proposed in 1961.

3. *Relation of costs to obligations.*—The relationship is derived from year-end balances of selected resources as reflected in the following table:

	1958 actual	1959 actual	1960 estimate	1961 estimate
Selected resources at end of year (inventories and items on order):				
Unpaid undelivered orders (appropriation balances obligated for goods and services on order not yet received)	$22,163,679	$33,475,086	$76,911,000	$127,698,000
Advances (payments for goods and services on order not yet received)	615,223	23,116	100,000	100,000
Total selected resources at end of year	22,778,902	33,498,202	77,011,000	127,798,000
Selected resources at start of year (−)		−22,778,902	−33,498,202	−77,011,000
Obligations incurred for costs of other years, net		10,719,300	43,512,798	50,787,000

Mr. THOMAS. Your justifications state as follows:

This appropriation provides for the modernization of existing facilities, the construction of new facilities including design by contract, and the purchase of major items of equipment. The costs shown in 1961 include those related to projects authorized in prior years. The principal projects proposed for construction in 1961 are as follows: Langley Research Center, where the proposed projects include an aerothermal dynamics facility to simulate the environment of vehicles in the hypersonic speed ranges—

and so forth.

The Ames Research Center, where you are requesting additional equipment for a centrifuge to test the effects of high acceleration in space vehicle equipment, and that is the small one at $980,000.

At Lewis Research Center you propose to construct a basic materials research laboratory and a laboratory for research on energy conversion and power generation processes and equipment.

At the Flight Research Center—that is one of your big ones down in Florida——

Mr. ULMER. No, that is at Edwards.

Mr. THOMAS. This is Muroc?

Mr. ULMER. Yes, sir.

Mr. THOMAS. Then, you have your space flight development and operation facilities which include the Goddard Space Flight Center where the proposed construction in 1961 consists of a payload test facility, a satellite system laboratory, and utility installations.

You have two laboratories there and are buying a piece of land and your utilities, which runs into money.

At the Wallops station the improvements to be added in 1961 include a system to determine the precise trajectory of launched vehicles, an operations computing center, and the modernization of certain existing support equipment.

So, you will have a computing center where? At Wallops and Goddard and where else?

Dr. GLENNAN. Every place.

Mr. THOMAS. At each one of them?

Dr. DRYDEN. This is a small computer costing $350,000 in connection with the operations of the Wallops Station.

Dr. SILVERSTEIN. In the firings and other tests necessary to take readings of the upper winds before firing, for range safety these data have to be calculated immediately before the firing and they establish the angle at which you fire.

UNOBLIGATED BALANCE

Mr. THOMAS. What is your unobligated balance for 1960 now for the construction and equipment program? What is it as of January 1 and what will it be on the 30th of June of this year?

Mr. ULMER. I can give you the January 31 figure, Mr. Thomas. The total approved cost for the 1960 program is $88,825,000 and the amount that is under contract is $40,042,000.

Mr. THOMAS. Will that figure hold to the end of the year? What will it be by June 30?

Mr. ULMER. I cannot give you an estimate on that except I am sure that a substantial portion of this unobligated balance will be under contract.

Mr. THOMAS. Can you make a horseback opinion and straighten it out later in the record?

Will you have a $20 million unobligated balance or $30 million or what?

Mr. ULMER. I would guess about $18 million or $20 million.

Mr. THOMAS. What is your unobligated balance now in your research and development account as of January 1 and what will it be by June 30?

Mr. ULMER. The research and development account is $320 million for 1960. On January 31 we had an unobligated balance of $105 million. I believe a fair estimate would be that on June 30 we would have $20 million of that unobligated.

Mr. THOMAS. $20 million unobligated?

Mr. ULMER. Yes, sir.

Dr. GLENNAN. I should think it would be less than that.

Dr. DRYDEN. I think it will be considerably less.

Dr. GLENNAN. You are only through 7 months of the year and you have obligated more than two-thirds of it already.

Mr. THOMAS. Did you include your supplemental in your figures though? You had around $22 million in that.

Mr. ULMER. $23 million.

The supplemental is not in those figures, Mr. Thomas, but that sum will very likely be obligated within 30 days after it becomes available.

ESTIMATES FOR CONSTRUCTION AND EQUIPMENT

Mr. THOMAS. I note this is a good table on page 306 and, of course, you can look forward to pages 307 and 308.

Take, now, for your Langley Center you had $4,535,000 last year and this year it goes up to almost $12 million.

At Ames you had $6,305,000, and that is a small one this year. That is the centrifuge you are requesting for $980,000?

Dr. GLENNAN. Yes, sir.

Mr. THOMAS. At Lewis you had $6,660,000 for 1960 and that goes up to $9,100,000?

Dr. GLENNAN. Yes, sir.

Mr. THOMAS. And you had at your Edwards Air Base $1,850,000 last year.

Your Goddard Space Flight Center was $14,070,000 last year and you are requesting $9,500,000 this year.

At Wallops Station you are requesting $4 million in 1961 as against none last year.

At your Jet Propulsion Laboratory you had $7,755,000 in 1960 and you are requesting $5 million for 1961.

At your Huntsville facility you are requesting $26,750,000.

At your Atlantic Missile Range you are requesting $27,750,000.

For your Minitrack net there was $4,205,000 last year and you are requesting $4,750,000 for 1961.

For your deep space net you had $3,500,000 in fiscal year 1960 and you are requesting $8 million for fiscal year 1961.

TRACKING STATIONS

How much do you have tied up in your tracking stations and equipment?

You have about $32 million under "Research and development" and how much under "Construction"?

Mr. ULMER. We have $27,750,000 being requested for 1961, Mr. Thomas.

Mr. THOMAS. Plus your $32 million for operations under research and development? Of course, under your research and development you have salaries and everything else mixed up in it.

Mr. ULMER. Only for the salaries of the contractor's people, but not our own people. That $32 million figure is mainly for station operation contracts and for data transmission contracts.

Mr. THOMAS. I looked it over and figured that you had around $77 million tied up.

Dr. GLENNAN. That is in "Construction."

Mr. THOMAS. It is about $77 million.

Mr. HORNER. Through fiscal year 1961.

Mr. THOMAS. And that is not all of it. You inherited about 18 stations from the IGY, and you have not added that in. So you have in the neighborhood of $90 million tied up in tracking stations. What part of that $90 million is going to be a recurring cost? Is all of your $32 million going to be a recurring cost under research and development?

Dr. DRYDEN. It will be the annual operations cost of the stations; yes, sir.

Mr. THOMAS. It is a recurring cost, then?

Dr. GLENNAN. The annual cost for maintenance and operation of those stations will be somewhere between $30 or $35 million a year.

Mr. THOMAS. Who are the operators of your stations?

Dr. GLENNAN. In some instances they are companies like Bendix and in some instances they are universities in the country in which the station is located; the Smithsonian Institute operates some, also.

Mr. THOMAS. Can you give us a list of your stations and your operators now under research and development and the fee which you are paying to operate each one of them on an annual basis?

What is your yardstick? How much money do you let them make?

Dr. GLENNAN. If it is the same fee I am thinking about, I do not think we have a contract of over 6½ percent.

Mr. THOMAS. Based upon what?

Dr. GLENNAN. On the negotiated contract price.

Mr. HORNER. The negotiated cost based on local man-hours for hiring local personnel, depending upon who we negotiated with. In many cases we negotiated with nonprofit institutions, and in other cases we negotiated with American industry. It is different at almost every station.

Dr. DRYDEN. In Australia we currently have no operating cost because they have agreed to operate the station in return for use of the facilities for scientific purposes when not tracking our satellites. In the future, there will be some reimbursement based on negotiations.

Dr. GLENNAN. And, that is true in South Africa also.

Mr. THOMAS. How many stations do you have in the continental United States?

Dr. DRYDEN. I do not have the details here.

Mr. THOMAS. Is it 4, 5, or 6?

Dr. DRYDEN. It is more than that.

Mr. THOMAS. You have two on the Pacific coast and you have three in the Northwest and the Northeast. Could that number be seven?

Dr. SILVERSTEIN. It is certainly less than seven. In the United States we are largely making use of existing stations. For example, in our MERCURY net we are using the Mugu organization, the Canaveral organization and the Eglin Air Force Base as well as the White Sands stations.

Mr. THOMAS. You are paying for it? You are paying for the maintenance and operation and the salary cost of the operator and you are maintaining it generally?

What is the yardstick which you use in figuring the compensation to be paid to the operators of these stations in the United States?

Dr. GLENNAN. Do you have that, Dr. Dryden?

Dr. DRYDEN. We have this collected and we can get it to you, but I do not have it myself.

Dr. GLENNAN. We shall put that in the record for you, Mr. Chairman.

Mr. THOMAS. Does anyone have a horseback opinion and then you may straighten it out later for the record?

Mr. HORNER. We are not paying the Department of Defense for operating stations except for the incremental costs where their cost of operating has been increased because of our requirements. In general, this amounts to equipment costs where they have had to add special equipment.

Mr. THOMAS. Who is operating your six or seven stations in the United States? Let us get that straight.

Mr. HORNER. The minitrack stations and the Smithsonian stations we are paying for, but that will have to be provided.

(The information requested follows:)

NASA TRACKING STATIONS IN THE UNITED STATES

The NASA currently owns or makes use of four categories of tracking stations in the United States and overseas. These categories are minitrack stations, the deep-space net, the optical stations, and the special-use Able–4 stations.

Of the 10 minitrack stations currently in operation, 3 are in the United States: Blossom Point, Md.; Fort Meyers, Fla.; and San Diego, Calif. These three stations and four of the overseas stations are operated under contract with the Bendix Aviation Corp. The total cost of this contract during fiscal year 1960 is $2,018,000, including a 6.02 percent fee of $115,750. Since the contract is not written on a station-by-station basis, only an estimate of individual station operating costs can be made:

Blossom Point	$301,691
Fort Meyers	320,660
San Diego	263,954

Of the three deep-space stations, only Goldstone, Calif., is currently operational. This station is being run by the Jet Propulsion Laboratory at a cost of $1 million in fiscal year 1960; NASA pays approximately $17,000 to the Jet Propulsion Laboratory (California Institute of Technology) for overhead and management of the Goldstone Station.

Of the 12 operating optical stations, 3 are in the United States: Jupiter, Fla.; Organ Pass, N. Mex.; and Maui, Hawaii. These 12 stations are operated for NASA by the Smithsonian Astrophysical Observatory, part of the Smithsonian Institution. The total grant to the SAO for this purpose is $1,450,000 in fiscal year 1960, no fee being required. Again, only an estimate of individual station operating cost can be made:

Jupiter	$101,500
Organ Pass	245,630
Maui	147,465

The special-use Able–4 stations are at South Point, Hawaii, and Cape Canaveral, Fla. These stations are used only in connection with payloads built for NASA by the U.S. Air Force. Intermittent operation of these stations is therefore funded as part of the payload cost paid to Ballistic Missile Command of the U.S. Air Force and is not separable from that total. No fee is involved since this is an intragovernmental transfer.

LANGLEY RESEARCH CENTER

HYPERSONIC AEROTHERMAL DYNAMICS FACILITY

Mr. THOMAS. Your big item down here at Langley is the hypersonic aerothermal dynamics facility in the amount of $11,957,000.

We shall insert at this point in the record page 309 of the justifications.

(The page referred to follows:)

HYPERSONIC AEROTHERMAL DYNAMICS FACILITY

1. DESCRIPTION

This project proposes the construction of a facility for simulating vehicle environment in the hypersonic-speed ranges. As indicated in the drawing on the following page the facility will consist of two main systems, one using air and the other using helium. The air system will be located in the west wing of the gas dynamics laboratory, and the helium system will be located in an extension to the west wing.

The system using helium as the test medium is required primarily for aeroelastic studies. This system will have two legs with test sections approximately 4 feet in diameter, one providing test speeds up to mach 10 and the other to mach 20; each leg will be capable of heated operation up to 650° F. Running times will be of the order of 20 seconds.

The other system will employ air and will be used primarily for the study of aerothermal problems. The air for this system will be stored at 15,000 pounds per square inch; this pressure will be obtained by a topping compressor that will draw on an existing 1,800-pounds-per-square-inch air supply. This system will also have two legs. One leg (the hyperthermal leg) will employ continuous-arch heating from a 10,000-kilowatt direct current to generate temperatures in the 7,000° R. to 16,000° R. temperature range. Interchangeable throats and liners for the water-cooled conical nozzle will be used to produce simulated velocities, altitudes, and temperatures in the mach 12 to 20 flight regime. Running times up to 3 or 4 minutes are expected. The temperature and pressure potential of this leg will open the way to even higher velocities as the state of the art advances in arc generation at high pressures. The other leg of the air system (the superpressure leg) will consist of a superpressure zirconia pebble heater capable of supplying 4,500° R. air at pressures up to 15,000 pounds per square inch. Running times of about 20 seconds are expected for this leg.

Mr. THOMAS. Your justifications state as follows:

This project proposes the construction of a facility for simulating vehicle environment in the hypersonic-speed ranges—

and so forth.

Then, you have this followed by a very nice drawing.

Mr. JONAS. That is just a glorified wind tunnel; is it not?

Dr. GLENNAN. That is right.

Mr. THOMAS. Your justifications at page 311 state as follows:

The lack of solution to urgent problems in the hypersonic-speed range is seriously retarding the conception and efficient design of new vehicles and the improvement of a wide variety of existing and planned vehicles which must reenter the earth's atmosphere from orbital or space flight or be capable of sustained flight at hypersonic speeds. The study of these problems cannot be undertaken without advances in the capability of simulating the vehicles' environment beyond that obtainable with present-day research facilities. At present there are no large air tunnels capable of exceeding mach 12 for significant testing times, and these wind tunnels are not yet capable of simulating the temperatures, velocities, and air densities of flight to this mach number.

So, we have to have these or else we cannot carry out our job. However, I notice we have not lost any personnel down there all this time.

Mr. ABBOTT. That is right. We need this in order to carry on our job.

Mr. THOMAS. What do you need with all the personnel you have down there until you get this constructed? The completion time, as well as I remember, is 36 months.

Mr. ABBOTT. I do not think that the fact that we need this bears very much on what our existing personnel are doing. They are working on extremely urgent projects.

COST ESTIMATE

Mr. THOMAS. We shall insert at this point in the record pages 314 and 315 of the justifications.

(The pages referred to follow:)

Cost estimate

Helium heating system and pebble heater		$434,000
Helium heating system	$311,000	
Pebble heater and ceramics	123,000	
Electrical equipment and power system		1,236,000
Outdoor switchgear primary cable and substation construction	$75,200	
10,000-kilowatt industrial ignitron rectifier	663,500	
Regulating equipment	71,400	
Resistor	95,700	
Secondary cable and control	127,600	
Arc starting equipment	76,500	
Auxiliary unit substation	58,600	
Starter group assemblies and auxiliary controls and wiring	67,500	
Equipment foundations and housing, building and utility revisions, and additions		479,000
Alterations to existing building and utilities	$138,000	
Building addition and mechanical hoisting equipment	201,000	
Equipment foundations	140,000	
Settling chambers, arc chamber, and test section		1,615,000
Settling chambers and arc chamber	$230,000	
Nozzles and test section	657,400	
Model support systems	575,100	
Mechanical parts of Schlieren systems and second minimum	152,500	
Pressure, vacuum, helium, and air piping		613,000
Water cooling system and aftercooler		329,000
Air, helium, and vacuum storage		963,000
15,000 p.s.i. air storage	$120,000	
5,000 p.s.i. helium storage	145,000	
100-foot-diameter sphere for air leg	573,000	
60-foot-diameter sphere for helium leg	125,000	
Controls		311,000
Multistage vacuum pumping and air dryer for the air system		675,000
Additional helium purification equipment and modifications to existing system		382,000
Instrumentation		700,000
Data recording equipment	$175,000	
Force measuring instrumentation	143,000	
Pressure measuring instrumentation	120,000	
Temperature measuring instrumentation	40,000	
Optical instrumentation	40,000	
Recording and readout equipment	103,000	
Programer and test parameter instrumentation	79,000	
Design and engineering services		220,000
Total estimated cost		7,957,000

Construction schedule.—Total estimated completion time, 36 months.

Dr. DRYDEN. May I add one word? Our long-range plans show a flight around the moon and back in about 1968. I would say that we have to have results from this facility before we know how to get that vehicle there and back safely. I think you are up against the problem I have already mentioned, that there is the leadtime in building a new launching vehicle, and that behind that is a leadtime in the basic research which must provide the knowledge necessary before

we can build the vehicle. If you do not obtain this basic knowledge, you will waste an awful lot of money in the process of trying to build a vehicle which will do the job. I think this facility is timed pretty well insofar as this commitment date for return from flight around the moon is concerned.

Mr. THOMAS. I note that there is an item in the amount of $479,000 for equipment foundations and housing, building and utility revisions, and additions.

How did you arrive at that figure?

For alterations to existing building and utilities there is the amount of $138,000.

For building addition and mechanical hoisting equipment there is the sum of $201,000.

For equipment foundations there is the sum of $140,000.

How did you arrive at these figures?

Dr. GLENNAN. That adds up to the $479,000.

Mr. ABBOTT. Figures of that sort, Mr. Thomas, are the easiest ones to arrive at, since this is standard, we know what it will cost in that area.

Mr. THOMAS. You say they are the easiest to arrive at? Mr. Abbott, are you in the construction and contracting business?

Mr. ABBOTT. I am not personally, no, sir; but we do have people at Langley who are doing this sort of thing all the time.

Mr. THOMAS. Are they going to do it at Langley or is this going to be let out on open competitive bids?

Mr. ABBOTT. It will be let out on competitive bids, but this estimate is based on their experience.

Mr. THOMAS. Is this a bidder figure?

Mr. ABBOTT. No, sir; this is not a bidder figure.

Mr. THOMAS. Whose figure is it?

Mr. ABBOTT. This is a figure from the engineering group at Langley which is responsible for this type of work and who have a great deal of experience in this work.

Mr. THOMAS. I thought this job was done here in the central office. You do not mean to tell me you have a contract group at each one of your installations, do you?

Mr. ABBOTT. We have an engineering group at each one of the installations which does this type of work and we also have a contract group which handles contracts at each installation.

Mr. THOMAS. The central office does not have anything to do with this? It is all handled down at Langley?

Mr. ABBOTT. No, sir; we give general approval to the scope and direction of the project.

Mr. JONAS. Do you do your own A. & E. work?

Mr. ABBOTT. Do you mean architectural and engineering work?

Mr. ULMER. For the most part, we try to contract that. On all standard building construction it is contracted; on the more special type of work we may have to do it ourselves.

Mr. JONAS. These figures precede your A. & E. work?

Mr. THOMAS. No; they set up $220,000 in here for that.

Mr. JONAS. These figures precede it?

Mr. ULMER. You are right.

Mr. JONAS. These are supposed to be just rough estimates?

Mr. ULMER. They are estimates by competent engineering people, who have built many——

Mr. THOMAS. Not anything like this.

Mr. ULMER. You are correct, but practically all of our facilities were specialized and were unusual at the time they were built, and these people have had experience in doing that kind of job.

Mr. THOMAS. Well, they are in the wrong kind of job. If they have had experience such as that, they should be in the construction business.

Mr. ABBOTT. Yes, sir. There is not a one of them who cannot make a great deal more money by going out and doing it, and we have had some who have done it. However, it would be a sad day if the Government were deprived of these people.

Mr. THOMAS. You are very convincing.

What is the turnover among this group?

Mr. ABBOTT. The turnover is small. There is also a certain element of glamor, if you will, I would prefer to say an element of challenge and interest to it. The opportunities seldom arise where people can do this kind of challenging work.

Mr. JONAS. Would you say one of the engineers who compiled these figures would try awfully hard not to underestimate the costs?

Mr. ABBOTT. What he tries to do is estimate them as closely as he can and not add anything to it.

Mr. JONAS. Do you not think he adds in about 15 percent or 20 percent for a safe margin?

Mr. ABBOTT. No, sir.

Mr. THOMAS. He has already figured most of this. I do not know why he put in $220,000 if he is a capable design man. I guess he can design it for $220,000. To whom is he going to give that if he has already done that work?

Mr. ULMER. He has done the preliminary engineering only to the point of being able to make a reasonable cost estimate. The big job comes after the money is available; detailed specificiations and drawings have to be prepared which can be put out on bid, and this is what the $220,000 is for.

Dr. DRYDEN. This is the relationship we have always enjoyed with this committee: We could go ahead and design something in detail, come in with a figure for the cost as the result of the design, and if for various reasons that amount of money was not available, do the design over again to stay within the limitation of the money available. We believe the procedure of requesting funds on the basis of estimates made just as reasonably as we know how to make them, and then preparing detailed designs after funds are appropriated is a more economical procedure.

Mr. JONAS. These figures were gotten up last summer?

Mr. ULMER. That is right, sir.

Mr. JONAS. They have no relationship to costs which will be in existence after July 1?

Mr. ULMER. That is true, Mr. Jonas, but from our past experience, costs have usually gone up.

Mr. JONAS. You do not expect them to go down?

Mr. ULMER. It is seldom that they go down.

Mr. THOMAS. You know, Dr. Dryden is one of the best contractors in this country, and we used to make a trade with him and we recom-

mended his construction. When he gets through with it, it is always good. Off the record.

(Discussion off the record.)

DYNAMICS RESEARCH LABORATORY

Let us look at the research laboratories here.

At this point in the record we shall insert pages 316, 318, and 319 of the justifications.

(The pages referred to follow:)

LANGLEY RESEARCH CENTER FISCAL YEAR 1961 ESTIMATES

DYNAMICS RESEARCH LABORATORY

1. Description

This project provides for the construction and instrumentation of a research laboratory designed to study dynamics problems of high performance aircraft, missiles, space vehicles, space stations, and satellite packages in simulated density, temperature, acceleration, and vibration environments. A drawing of the proposed facility is shown on the following page. The Laboratory will provide the capability for study of both the structural dynamics of the vehicles and their components, and the free-body dynamics with respect to space orientation control, guidance, and navigation. Configurations envisioned include erectable space structures and parallel boost configurations, as well as the more conventional configurations. The following items are proposed for construction and installation under this project:

(*a*) A modernization of the vibration facilities of the Langley Center, including the addition of required shakers ranging from an increase in the present number of 50-pound capacity shakers to electronic and hydraulic vibration systems up to 25,000-pound capacity. The electronic systems will be capable of supplying sinusoidal as well as complex random force inputs to structures and instrumentation packages.

(*b*) A large backstop capable of handling dynamic models of space stations, space vehicles, and boost configurations; components of full-scale space stations, vehicles, and boost systems; and satellite packages and vehicle instrumentation packages.

(*c*) An environmental heat and hard vacuum chamber capable of simulating atmospheric density and heat conditions of hypersonic flight while simultaneously conducting vibration, acceleration, and fatigue research on vehicle structural and instrumentation components and control systems.

(*d*) A whirl table capable of providing large acceleration fields simultaneously while simulating other vibrational and flight environments.

(*e*) Simulation equipment to provide means for the study of gain and phase effects in semimechanical and analog studies of structural servo feedback induced vibrations and instabilities, and for the control and programing of environmental test conditions; provisions are included for a tie-in to existing computing facilities at the Langley Center.

(*f*) A shock and impact loading table to simulate and study effects of shocks loads arising from conditions such as boost ignition and burnout, stage separation, and landing impact.

(*g*) Apparatus for simulating electromagnetic field and other environmental effects on the spin stabilization of space vehicles and packages; apparatus to provide free suspension of space orientation control and guidance systems and stabilized vehicles; and apparatus to provide suitable radiation simulation of celestial space reference bodies.

(*h*) A vacuum sphere 60 feet in diameter for the study of space orientation control, guidance, and navigation.

(*i*) A vacuum cylinder 60 feet in diameter and 60 feet high with provisions for the installation of the whirl table and with provisions for studying the behavior of large space vehicle components at high altitudes, including the behavior of erectable structures.

(*j*) A building for offices, shops, setup and control of tests, computing and data reduction equipment, and support machinery.

(*k*) The necessary vacuum pumps to complement the equipment presently available at the Langley Center and to permit pump down of either the vacuum sphere or the cylinder to a moderate vacuum in approximately 2 hours.

2. Justification

The development of satellites in the United States has been greatly hampered by lack of adequate facilities for research information on problems in dynamics and hence has proceeded on a cut and try, ad hoc test basis. The dynamic characteristics of vehicles are basic ingredients in the analysis of design for efficient performance and structural integrity. Lack of information on the dynamic characteristics has contributed to failures. Many of these have been caused by broken and malfunctioning equipment due to large repeated loads which lead to high vibratory response and fatigue of vehicle elements. The motions of the fuel and the vibratory deformations of the vehicle, coupling with the control system, as well as unbalance of the spinning payloads have also caused loss of vehicles. The future ferry-reentry vehicles, space stations, and vehicles for landing on the moon will generate many dynamics problems which must be solved.

Loss or malfunction of vehicles could be avoided and a more efficient structure could be obtained by appropriate applied research and by more comprehensive proof testing of the vehicle components and payloads under conditions which more nearly simulate the combined environments which the vehicles will experience. The Laboratory under this project is designed primarily to provide simulated environments, from launch to orbit to landing, for research to obtain the structural efficiency and integrity demanded for high performance and to insure the reliable operation of the vehicle.

Mr. THOMAS. I have noted here one laboratory building, an office building, and a shop building.

Your justifications state as follows:

This project provides for the construction and instrumentation of a research laboratory designed to study dynamics problems of high performance aircraft, missiles, space vehicles, space stations, and satellite packages in simulated density, temperature, acceleration, and vibration environments.

Here is the drawing and I commend it to you.

COST ESTIMATE

We shall insert into the record at this point pages 320 and 321 of the justifications.

(The pages referred to follow:)

Cost estimate

Building		$519,000
Utilities and paving		65,000
Backstop and foundation		550,000
Impact and shock table		30,000
Cranes		49,500
Vacuum system		723,500
Environment test cell		112,500
Centrifuge		104,500
Electrical systems		530,000
Instrumentation		1,200,000
Vibration test system	$350,000	
Weights, balances and accessories for backstop	75,000	
Orientation and stablization equipment	300,000	
Radiation simulation system	100,000	
Simulation computer system	75,000	
Data recording and readout equipment	100,000	
Auxiliary laboratory instrumentation	200,000	
Shop equipment and furniture		22,000
Design and engineering services		94,000
Total estimated cost		4,000,000

Construction schedule.—Total estimated completion time, 24 months.

Mr. THOMAS. With reference to your building, I have a notation here as to the number of square feet but I have forgotten what it was. However, the cost is in the amount of $519,000.

How many square feet are in the building?

The utilities and paving come to $65,000. Your backstop and foundation comes to $550,000.

How many square feet are in this building?

Mr. ULMER. I do not have that information, sir.

Mr. JONAS. It is to be a building 160 by 100 feet, is it not?

Mr. THOMAS. I think this is the only one where they did not give the square footage. They gave it in all the rest of them.

Mr. ULMER. I think you are right, Mr. Thomas.

Mr. THOMAS. Can you figure it out right quick for us?

Dr. DRYDEN. It is, roughly, 16,000 square feet.

Mr. ULMER. We must bear in mind that this is a two-story building.

Mr. THOMAS. What does it cost you a square foot?

What do you mean by your "backstop and foundation" in the amount of $550,000?

That makes your building already cost $1,130,000.

Dr. DRYDEN. The backstop is a big concrete and steel mounted structure on which you install and support the items to be tested.

Mr. THOMAS. Is that the foundation?

Dr. DRYDEN. No, it is a free-standing structure, in the middle of this big hall, to which you can fasten machines.

Mr. THOMAS. Do you mean your overhead cranes?

Dr. DRYDEN. There is an overhead crane in there, I believe, to handle the pieces of equipment.

Mr. THOMAS. I note that your crane is listed at $49,500.

Mr. ABBOTT. I figure the floor area at 16,400 square feet, unless I made a mistake.

Mr. ULMER. That is right. I checked it.

Mr. THOMAS. What will it cost you a square foot? What will it be constructed of? Will it be built with a concrete floor?

Mr. ULMER. Yes, it is generally that type of construction.

Mr. THOMAS. Will it be a loft-type building?

Mr. ULMER. That is just about $30 per square foot.

Mr. THOMAS. $30 a square foot?

Mr. ULMER. Yes, sir.

Mr. THOMAS. Are there any offices or anything like that in it?

Mr. ULMER. Very limited. It is mostly nonoffice space.

Mr. JONAS. That does not count this backstop and foundation, does it?

Mr. THOMAS. Is it $30 a square foot without the equipment which goes into it?

Mr. ABBOTT. The backstop and foundation, as Dr. Dryden says, is a very heavy free-standing steel and concrete structure with very heavy construction. So, it is an extremely solid item to which models, or whatever is going to be tested, can be fastened. At the point they are fastened to the structure they will not move in any respect. This sort of thing is used to provide solid support to the items to be tested.

Mr. THOMAS. Still, the building will cost $30 a square foot with all the equipment?

Dr. DRYDEN. The building itself costs less than that backstop. The building itself costs $519,000.

Mr. THOMAS. How much is that a square foot?

Mr. HORNER. There are 16,400 square feet.

Mr. JONAS. About $30 a square foot?

Mr. ABBOTT. It is about $30 a square foot.

Mr. JONAS. That does not include the equipment?

You have an electrical system in the amount of $530,000; you have cranes in the amount of $49,500; you have a vacuum system in the amount of $723,500.

How does he arrive at all these items here?

Mr. ABBOTT. On items like cranes you can just about pick them out of a catalog, also on items like the vacuum system. Some of the items can just about be picked out of a catalog and others can be calculated on the basis of so much per pound for steel and this sort of thing on the basis of past experience and current prices.

Mr. THOMAS. Do the figures include the installation costs?

Mr. ABBOTT. Yes, sir; these figures are intended to give a completely furnished installation.

Mr. THOMAS. You have a design and engineering cost in the amount of $94,000 and furniture and equipment in the amount of $22,000 and you have 24 months' leadtime.

AMES RESEARCH CENTER

CENTRIFUGE EQUIPMENT

With reference to your centrifuge here at Ames, you are going to modernize an existing facility?

Mr. ABBOTT. Yes, sir.

Mr. THOMAS. This is the smallest cost you have. I believe it is in the amount of $980,000?

Mr. ABBOTT. Yes, sir.

Mr. THOMAS. And you have a leadtime of 8 months.

You have computer equipment here in the amount of $390,000?

Mr. ULMER. Yes, sir.

Mr. ABBOTT. These centrifuges are controlled by the computer equipment and at the present time we are using the computer equipment which is supposed to service the laboratory. That means that when the centrifuge is being used, it is not available for anything else. This project will provide a computer for this piece of equipment.

LEWIS RESEARCH CENTER

ENERGY CONVERSION LABORATORY

Mr. THOMAS. Let us take a look at Lewis where you have two laboratories, one for energy conversion and one for materials.

Your justifications state as follows:

> This project proposes the construction of an integrated complex of facilities for a broad research program on energy conversion and power generation processes and equipment. Major components of the facility comprise highly specialized equipment and instrumentation, suitable laboratory spaces for the equipment, control rooms and required services, as follows.

We shall insert into the record at this point pages 325, 326, and 328 of the justifications.

(The pages referred to follow:)

LEWIS RESEARCH CENTER, FISCAL YEAR 1961 ESTIMATES

ENERGY CONVERSION LABORATORY

1. Description

This project proposes the construction of an integrated complex of facilities for a broad research program on energy conversion and power generation processes and equipment. Major components of the facility comprise highly specialized equipment and instrumentation, suitable laboratory spaces for the equipment, control rooms and required services, as follows:

Radiant energy conversion facilities.—Equipment to produce a variety of radiant energy sources, including electromagnetic waves, and neutron beams of various energies; and equipment for preparing special cells, and related devices.

Thermal energy conversion facilities.—Equipment to provide thermal energy sources, and instrumentation and apparatus for testing and evaluating systems.

Chemical properties equipment.—Advanced instrumentation for ascertaining properties of matter in its various states in support of energy conversion research as well as other researches at the laboratory pertaining to propulsion and space research.

Liquid metal pump facility.—A test facility for pump research including cycle heater, condenser, research pump, prime mover, flow control instrumentation and liquid metal storage and purification equipment.

Liquid metal turbine facility.—A closed-loop turbine rig including boiler, research turbine, condenser, service pump, power absorber, controls and instrumentation.

Systems dynamics and cavitation facility.—A small scale closed-loop rig including pump, heat exchanger, lines and ducting, test sections, supply tank and special devices for studying fundamental dynamics and cavitation characteristics of liquid metals.

Liquid metal heat transfer facility.—A multiclosed loop heat transfer rig involving fluid supply tank, pumps, test section, heat source, purging and cleaning equipment and instrumentation for studying convectors, nucleate boiling, condensation and evaporation phenomena of liquid metals at temperatures from 1,000° to 2,500° F.

Friction and lubrication apparatus.—A friction test rig and vacuum chambers for investigation of bearings and seals for liquid metal applications.

A drawing of the proposed energy conversion laboratory is presented on the following page.

2. Justification

A prime requirement for effective space flight and space exploration is lightweight, efficient electrical production devices. Not only is the need for lightweight and high efficiency very great, but the power requirements for future space vehicles vary over extremely wide ranges of duration, average power, and peak power. To adequately meet these requirements, a broad research program on a wide variety of energy conversion processes is essential. Such a program must encompass exploratory, basic research on various concepts of direct conversion processes, applied research on turboelectric system components, research into the heat transfer and thermodynamic and hydrodynamic characteristics of novel working fluids.

Exploratory research on direct conversion processes includes the production of electrical energy from heat and radiation of various kinds. Typical concepts requiring experimental investigation are photovoltaic cells of various kinds, photogalvanic cells, microwave amplifiers, thermopiles, plasma diodes, and utilization of energy gaps in semiconductors or artificial metals. Such direct conversion methods offer the promise of improved reliability for long-term space missions through the elimination of rotating machinery. The theoretical efficiences are comparable to those of conventional electric power generation equipment. The direct conversion devices also hold promise for improved lifetime against meteoroid penetrations of the powerplant waste heat radiator.

To achieve lightweight, turboelectric systems requires vaporized and liquefied metals at high temperatures as the working fluid. There are therefore introduced a host of new problems relating to the unusual hydrodynamic and thermo-

dynamic properties of these fluids as well as the design and operation of such high-temperature components as pumps, turbines, evaporators, and heat exchangers. To rapidly and effectively develop this new technology will require a well-coordinated research program on all these problems. Pumps must be capable of operating with these fluids near their boiling point; turbines must operate with high efficiency and with considerable moisture in the working fluid; the cavitation phenomena of liquid metals in valves and pumps need be determined; the mechanism of the flashing of the liquid into the vapor phase needs study; and knowledge of the general heat transfer, hydrodynamic and thermodynamic properties of these liquids and their vapors is virtually nonexistent.

3. Cost estimate

Building		$785,000
Site preparation and utility connections		190,000
Equipment		3,850,000
Radiant energy conversion equipment	$450,000	
Thermal energy conversion equipment	480,000	
Chemical properties equipment	340,000	
Liquid metal pump	390,000	
Liquid metal turbine	840,000	
Systems dynamics and cavitation equipment	160,000	
Liquid metal heat transfer equipment	620,000	
Friction and lubrication apparatus	570,000	
Design and engineering services		225,000
Total estimated cost		5,050,000

4. Construction schedule

Total estimated completion time, 27 months.

Mr. THOMAS. Your justifications at page 326 state as follows:

A prime requirement for effective space flight and space exploration is lightweight, efficient electrical production devices. Not only is the need for lightweight and high efficiency very great, but the power requirements for future space vehicles vary over extremely wide ranges of duration, average power, and peak power. To adequately meet these requirements, a broad research program on a wide variety of energy conversion processes is essential. Such a program must encompass exploratory, basic research on various concepts of direct conversion processes, applied research on turboelectric system components, research into the heat transfer and thermodynamic and hydrodynamic characteristics of novel working fluids.

Do General Electric and the Smithsonian Institute have any of these facilities, Mr. Abbott?

Mr. ABBOTT. There will be nothing in here, I believe, which is unique to this installation, but I do not know of anyone who has the complex requested here to permit attacking our problems from all directions.

Mr. THOMAS. You are practically doing over the laboratory there at Langley, are you not, in this regard?

Mr. ABBOTT. At Lewis, sir.

Mr. THOMAS. Is it Lewis or Langley?

Mr. ABBOTT. This is Lewis. This is a comparatively new field for us, and we do need this equipment to permit us to get into it properly.

Mr. THOMAS. You have a leadtime of 27 months.

What is all of that personnel which you have going to be doing all that time?

Mr. ABBOTT. Again, our problem at Lewis is not to find work for the personnel to do but to try to decide what we can properly undertake with the personnel which is there. Again, we will either have to stop some of the existing work which is needed or we will have to come back and ask you for additional people.

Mr. JONAS. Do they not do exactly the same thing at Wright-Patterson Air Force Base? Do they not have similar laboratory facilities there?

Mr. ABBOTT. They have laboratories at Wright-Patterson, but they do not have anything like this.

Mr. JONAS. They do not have any laboratories such as this?

Mr. ABBOTT. No, sir.

Mr. JONAS. You are sure?

Mr. ABBOTT. Yes, sir.

Mr. JONAS. You checked that?

Mr. ABBOTT. Yes, sir.

Mr. THOMAS. How large is this building?

Mr. ABBOTT. We have coordinated these facilities with the Department of Defense and some facilities have been dropped from the budgets in both instances, both theirs and ours.

Mr. THOMAS. How much is this building going to cost? Is that figure $785,000?

Mr. ABBOTT. Yes, sir.

Mr. THOMAS. For site preparation you have the amount of $190,000.

How many square feet are in this building? Is this going to cost $30 a square foot also?

Mr. ULMER. It has about 23,000 square feet in it, including the basement.

Mr. THOMAS. How much is that a square foot?

Mr. ULMER. A little over $30, I believe.

Mr. THOMAS. Well, is it going to contain offices or be loft space or what?

Mr. ULMER. Most of these are laboratory rooms.

Mr. THOMAS. For engineering and design there is the sum of $225,000 and the total cost of the equipment and building is $5,050,000.

How did you arrive at the cost of these components listed in here at $3,850,000 which include radiant energy conversion facilities in the amount of $450,000; thermal energy conversion equipment in the amount of $480,000; chemical properties equipment in the amount of $340,000; liquid metal pump in the amount of $390,000, and so forth? These are all new items with which you have not had any experience.

How did you come up with this construction figure?

Mr. ABBOTT. These items are items which can be obtained commercially and these figures are arrived at from the current prices for those pieces of equipment.

Mr. THOMAS. Does not the Bureau of Standards have any of this equipment?

Mr. ABBOTT. Yes, sir; they have certain types of it.

Mr. THOMAS. Can you get them to do this work for you?

Mr. ABBOTT. Not without providing them with the additional equipment and people with which to do it.

Mr. THOMAS. I thought you said they had some of this equipment now.

Mr. ABBOTT. Yes; and it is being used. Of course, the equipment that they have is for their purposes.

MATERIALS RESEARCH LABORATORY

Mr. THOMAS. Let us take a look at your Lewis research center and your basic materials research laboratory which you state is required to extend the scope and magnitude of the materials research capability to the field of space vehicles, and so forth.

This category will include equipment for basic research on ion and radiation damage, the chemistry and physics of surface under very high vacuum, the nature of imperfections in solids, elementary processes involved in the mechanical behavior of solids, chemical binding in refractory materials, and the chemistry of the reactions of dissociated gases with metals and ceramics at very high temperatures.

Are we doing this anyplace else?

Mr. ABBOTT. Yes. As you are aware, I think, Mr. Thomas, there is a considerable amount of materials work going on in this country and, as a matter of fact, it is being increased. There is concerted effort on the part of the Government, in several agencies, to increase this work. The amount of it done in NASA is small and will remain very small compared to the total amount going on after we man this piece of equipment.

Mr. THOMAS. How does this fit in with your atomic energy installation in Plumbrook?

Mr. ABBOTT. There are certain types of materials work here which will be very closely coordinated, such as the work on tungsten that I mentioned this morning. What we are trying to do here is pick up that part of the basic materials work which is associated with the space activities, in which other people are not——

Mr. THOMAS. Your language clearly indicates you are getting into space activity work. You kept a big personnel load there for 18 months. Now you are modernizing your equipment and finally getting into your new job. Is that true?

Mr. ABBOTT. Sir, we are already into it to a very large extent, but as is always the case in a rapidly advancing technology, such as this, new equipment and new skills have to be taken on board to supplement and to replace the older.

Mr. THOMAS. You express it better than I. I will read your language.

To meet expanding NASA research responsibilities it is mandatory that the scope and magnitude of the NASA materials research effort be substantially expanded, primarily to study the unique and entirely new materials problems that are encountered in space vehicles.

Let us take a look at your cost with a leadtime of 15 months. The building is $1,050,000; utility connections are $50,000. How many square feet are there in this building?

Mr. ULMER. Approximately 40,000, Mr. Thomas.

Mr. THOMAS. How much is that a square foot?

Mr. ULMER. About $26 a square foot.

Mr. THOMAS. Do you have any cafeteria, libraries, or any offices in this building?

Mr. ULMER. No cafeteria, no libraries. There will be some offices.

Mr. ABBOTT. Some offices, but primarily shop rooms.

Dr. DRYDEN. On page 330, the office is shown on the front of the building.

Mr. THOMAS. How much do you have in here for fallout shelters?

Mr. ABBOTT. That is not broken out separately, sir. I cannot give you that answer.

FALLOUT SHELTERS IN NEW BUILDINGS

Mr. THOMAS. Do you have fallout shelters in the other buildings we have just passed over?

Mr. ULMER. Yes, sir. All of the Lewis buildings have been designed with that requirement. I am sorry I did not bring the figures. You can have it first thing in the morning.

Mr. THOMAS. Do all of the new buildings you are constructing in this program have fallout shelters according to ODM regulations? Do you know what it is costing?

Mr. ULMER. I do not have the figures with me.

Mr. THOMAS. Did you ask for those fallout shelters?

Mr. ULMER. We did, sir. We were required to make the estimates include that provision.

Mr. THOMAS. I did not ask you that. I knew you were required, but I asked you if you asked for it.

Mr. ULMER. Yes, sir. I think the amount—I would rather not guess. I have it at the office. I will bring it in.

Mr. THOMAS. Off the record.

(Discussion off the record.)

Mr. ABBOTT. It has to be put in unless we get an exception.

Mr. THOMAS. Is it costing 5 or 10 percent of the total construction cost? What is the nature of the ODM fallout facilities?

Mr. ABBOTT. It is broken out for some of these facilities.

Mr. THOMAS. I did not read where you broke any of it out. You mentioned it in two or three of them lightly.

Mr. ULMER. I would like to check the record on that, Mr. Thomas.

Mr. THOMAS. I think the evidence so far has been it was 5 or 7 percent of the total cost of the building.

Mr. JONAS. Do you mean those shelters?

Mr. THOMAS. Yes. Mr. Floete told us it was either 5 or 7 percent. Does anybody have an idea of what the ODM extra cost is?

GODDARD SPACE CENTER

PAYLOAD TESTING FACILITY

Let us take a look at the Goddard Space Center. Here is the first time you mentioned ODM up to now. You are asking for a satellite systems laboratory and a payload testing facility.

I have a question here:

Do all buildings in the program have OCDM shelters; and you have just said "Yes."

It is proposed to construct an integrated laboratory to house the necessary facilities and personnel for the testing and evaluation of all scientific probes, payloads, or satellites developed by the Goddard Space Flight Center.

This is a testing laboratory?

Dr. SILVERSTEIN. Yes, sir.

As indicated in the drawing on the following page, the building will consist of a multistory office area for scientific and administrative offices intercon-

nected to a single-story laboratory area containing a high center bay with bridge crane and paralleled on either side by low bays for bulky research facilities, isolatable test cells, instrumentation rooms and supporting equipments. The building will provide about 60,000 square feet of space, including fallout shelters in accordance with OCDM requirements.

How many feet of fallout shelters have we got?

Dr. SILVERSTEIN. Adequate, I think, for the personnel to be used in the building.

Mr. THOMAS. Can you translate that into square feet for me?

Dr. SILVERSTEIN. I cannot, sir.

Mr. THOMAS. Will you do that for the record, please, sir?

Mr. ULMER. Mr. Thomas, as you know, the OCDM standards do not apply to every building. There are certain considerations regarding the size of the building and the function of the building, which determine whether or not a shelter is included. We will outline that in detail for you.

Mr. THOMAS. This is one of those?

Mr. ULMER. I would think so, yes.

Mr. THOMAS. Your justification clearly states.

What is this going to cost you a square foot?

Dr. SILVERSTEIN. In the order of $21 a square foot. It will average $21.

Mr. THOMAS. Are we going to show any reduction in rent when you build this building?

Dr. SILVERSTEIN. Yes, sir. We are currently renting space at NRL, providing a fee to them for their overhead.

Mr. THOMAS. How much money will you save in rent on construction of this building?

Dr. SILVERSTEIN. I think it will be somewhere in the order of—annual cost of around $200,000.

Mr. THOMAS. Saving, you mean?

Dr. SILVERSTEIN. Yes.

Mr. THOMAS. If that is true, you will pay for it in 6 years then. That is a good payout. That is the kind we like. Are you sure about your $200,000?

Dr. SILVERSTEIN. I can check it for you. I think it is about the right order.

Mr. THOMAS. Have you separate research facilities at your other installations for these different components that you are going to test? What about down at Huntsville? Do you have the same type laboratory down there?

Dr. SILVERSTEIN. We have some of these components at Huntsville, but not of the size that we are going to have here. Those at Huntsville are qualified to check out payloads of the size of the ones that have been used on the JUNO II vehicle, and the early EXPLORER I type vehicles. We are moving rapidly toward larger vehicles with larger satellites and payloads and we have to increase our capability for handling the larger size.

COST ESTIMATE

Mr. THOMAS. Put pages 337 and 338 in the record.
(The pages referred to follow:)

3. Cost estimate

Building construction	$1,250,000
Research equipment	2,230,000
Thermal-vacuum systems	860,000
Environmental test chambers	90,000
Vibration systems	300,000
Centrifuges	75,000
Shock testers	25,000
Mechanical test equipment	150,000
Balancing equipment	60,000
Nondestructive test equipment	75,000
Data handling systems	345,000
Combined environment facility	250,000
Design and engineering services	75,000
Total estimated cost	3,555,000

4. Construction schedule.—Total estimated completion time, 26 months.

Mr. THOMAS. Your building construction here is $1,250,000.

I have here $20-plus a square foot. You said $21. You have got $2,230,000 worth of equipment here; data-handling systems, $345,000, combined environment facility, $250,000. What is the combined environment facility?

Dr. SILVERSTEIN. That is a facility where you combine a capability providing a high vacuum with heating and cooling of the payload. This takes it through the environment experiences in space.

Mr. THOMAS. Leadtime is 26 months.

Gentlemen, let us quit and come back at 10 o'clock tomorrow. We ought to finish this tomorrow. You have another lab at Goddard that costs $1,750,000. I think we can get through tomorrow.

WEDNESDAY, MARCH 16, 1960.

SATELLITE SYSTEMS LABORATORY

Mr. THOMAS. Will the committee please come to order. The first item for consideration this morning under construction is the satellite systems laboratory at the Goddard Center. We shall insert pages 339 and 341 in the record.

(The pages referred to follow.)

SATELLITE SYSTEMS LABORATORY

1. Description

This project proposes the construction of a laboratory building that will provide the Goddard Center with facilities for the development and integration of large satellite systems. The building will provide about 100,000 square feet of space, including fallout shelters in accordance with OCDM requirements. A sketch of the proposed facility is presented on the following page. The building will include an enlarged cafeteria required for the increased staff, an auditorium for the center's technical and staff meetings, and provisions for a permanent library. As part of this project, the existing interim cafeteria equipment presently located in the space projects building will be moved and the area con-

verted to engineering design space in accordance with the original long-range plan for that structure.

2. Justification

The increased thrust being provided by current booster development programs will provide for increasingly larger and more complex satellite systems and payloads. The conception, construction, and integration of these complex systems requires additional facilities and personnel skilled in payload system integration and management.

Typical payloads are those for Nimbus and for the orbiting astronomical satellite. The Nimbus satellite, weighing upward of 600 pounds, contains television, electrostatic tape records, radiation sensors and scanners, and other instruments intended to study the meteorology of the earth. The satellite will contain an elaborate control system consisting of pneumatic and gyro wheel elements for stabilizing the satellite with respect to the earth. Thus, the cameras and other sensors will always be looking straight down at the surface. In addition, a near polar orbit is planned, which will result in much greater coverage. To design and integrate such a complex system as a complete unit, a process necessary for mission success, facilities, and personnel working together in a single area are needed.

Another larger and more complex payload is the orbiting astronomical satellite which will weigh more than 3,000 pounds and contain a vast array of astronomical instrumentation. From this highly stabilized platform, telescopes will be pointed to definite objects of the sky for astrophysical study. Still another type of payload weighing up to 3,000 pounds will be composed of separate satellite systems some of which will be ejected as individual satellites. All components of these systems must be brought together in a single area for integration and systems testing.

The work involved in the integration and testing of these payload systems includes the development of attitude orientation devices requiring gyro and jet stabilization systems; the development of precise steering controls for predetermined flight programs; the development of integrated satellite payloads including mechanical, power, and signal compatibility of various experiments or subsystems; the study of special trajectory requirements; flight stability analysis; and the development of separation techniques.

The implementation of this work requires a location at the Goddard Center with access to the instrument shops, the environmental checkout facilities, and the scientific staff developing the sensor components. The proposed building will enable the center to group its scientific, technical and administrative staff efficiently in accordance with their related functions.

3. Cost estimate

Building construction		$3,700,000
Research equipment		650,000
Gyro-test facility including associated computer	$400,000	
Checkout ground receiving and decoding equipment	200,000	
Shielded rooms	50,000	
Revisions to space projects building		70,000
Design and engineering services		216,000
Total estimated cost		4,636,000

4. Construction schedule

Total estimated completion time, 26 months.

Mr. THOMAS. You say on page 339 of the justifications:

This project proposes the construction of a laboratory building that will provide the Goddard Center with facilities for the development and integration of large satellite systems. The building will provide about 100,000 square feet of space, including fallout shelters in accordance with OCDM requirements. A sketch of the proposed facility is presented on the following page. The building will include an enlarged cafeteria required for the increased staff, an auditorium for the center's technical and staff meetings, and provisions for a permanent library. As part of this project, the existing interim cafeteria equipment presently located in the space projects building will be moved and

the area converted to engineering design space in accordance with the original long-range plan for that structure.

The increased thrust being provided by current booster development programs will provide for increasingly larger and more complex systems and payloads. The conception, construction, and integration of these complex systems requires additional facilities and personnel skilled in payload system integration and management.

Is there overlapping of this facility with either Huntsville, or the JPL laboratory?

Dr. DRYDEN. No, sir. This, as I explained yesterday, provides for payloads of 600 pounds and more. The one you see here is for about 900 pounds. Future payloads will be very much larger. They have to be shaken, heated, and cooled and their performance tested.

Mr. THOMAS. This laboratory can work with any type of payload. It is not confined to 600 pounds?

Dr. DRYDEN. The size of the thing you can shake depends upon the size of the shaking equipment you order. We have shaking equipment for the smaller payloads. We do not have it for the larger ones.

Mr. THOMAS. We are talking about the building.

Dr. DRYDEN. The building itself is to house the equipment.

Mr. THOMAS. You have 100,000 square feet here. I have an estimate here that the building will cost $3.7 million. That is $37 per square foot. Is that correct?

Dr. DRYDEN. That is correct.

Mr. THOMAS. There is a leadtime of 26 months?

Dr. DRYDEN. Yes.

Mr. THOMAS. You have a total cost for the building and equipment of $4,636,000.

What do you mean by "shielded rooms" as shown on page 341?

Dr. DRYDEN. In checking out the radio equipment, telemetry equipment, you put it inside of a room whose walls are covered with copper screens so outside radio signals do not get in.

Mr. THOMAS. How many rooms do you have?

Dr. SILVERSTEIN. These cost about $25,000 apiece to shield.

Mr. THOMAS. What do you shield with, one-sixteenth of an inch copper plating?

Dr. SILVERSTEIN. It is either copper sheet, or copper screen. It is done both ways. These rooms are standard. You practically buy them on the market.

Mr. THOMAS. How thick is the copper shielding?

Dr. SILVERSTEIN. It is quite thin.

Mr. THOMAS. How large will the rooms be?

Dr. SILVERSTEIN. I do not know exactly. I think 16 feet by 16 feet. That is a standard room.

Mr. THOMAS. Certainly they would not cost $25,000. What you are doing is plastering them over with copper plate?

Dr. SILVERSTEIN. The copper plate has to be completely sealed. The copper is soldered completely around the room. If you have leaks in it you will loose the full effectiveness of the room.

Mr. THOMAS. You show design and engineering services in the amount of $216,000.

Mr. JONAS. When you are prepared for bigger payloads than this will you have to build a new facility?

Dr. DRYDEN. When we come to the payloads for SATURN we will have to get larger equipment. I do not say we will have to get new buildings. I do not know at this time.

Mr. JONAS. If you have to build a new building to take care of a 600-pound payload and cannot expand existing facilities, it would seem to me to be almost inevitable when you increase your payload you are going to have to build a new facility?

Mr. HORNER. I would like to point out there is no such facility today. The payload preparation has been carried on thus far in rooms that have been built for other purposes where equipment has been added on a payload-by-payload basis. That facility will be the first integrated payload development facility of its nature, and it will have considerable growth potential.

Mr. THOMAS. Certainly the building can house most any type of payload. You have in the neighborhood of $1 million here for equipment.

Dr. DRYDEN. That is right.

Mr. THOMAS. For a 600-pound payload. Mr. Jonas raises the question whether you can use this same equipment for a 1,000-pound payload?

Dr. DRYDEN. It will cover such a range as that. It would not cover 20,000-pound payloads which SATURN would be able to put up.

Mr. THOMAS. How much money are you spending on your library construction and your cafeteria? How many people can you feed?

Dr. DRYDEN. The cafeteria will seat 800 and will serve the whole installation. I do not have the specifics on the library.

Mr. THOMAS. What kind of messing facilities do you have at Goddard now?

Dr. DRYDEN. Temporary messing facilities for the two buildings that are just being completed.

Mr. THOMAS. Do you have any messing facilities now?

Dr. DRYDEN. No, sir. The buildings are not yet occupied, but there will be a temporary facility set up on one of the larger rooms. The new cafeteria will serve the entire center.

Mr. THOMAS. How much money are you spending on the cafeteria and how much on the library?

Dr. DRYDEN. I do not have that breakdown. We can furnish that to you. The cafeteria is shown on the drawing on the previous page. It is a single story addition to the other structure.

Mr. THOMAS. $37 per square foot looks like mighty expensive construction to me.

Dr. DRYDEN. I am sure that particular bit does not cost that much.

Dr. SILVERSTEIN. The $37 a foot includes the laboratory benches and the electrical system to support the laboratory. In a laboratory of this type we have to have in each bench for the checkout of this equipment electric power over a wide range of voltage; high levels of power in some cases for the larger satellites. Also high pressure air vacuum systems, water and so forth.

Mr. THOMAS. You have close to $1 million in equipment?

Dr. SILVERSTEIN. The equipment is special research equipment, but does not include the normal laboratory bench type equipment that is provided in a laboratory building.

Mr. THOMAS. It is obvious from what you gentlemen say these costs estimates are the rankest sort of a guess.

FALLOUT SHELTERS

Mr. ULMER. I wonder if I could give you the figures at this point that I promised on the OCDM requirements because those costs are involved in this particular building?

There are four facilities in the construction program that have the fallout shelter cost included; the two at Goddard and the two at Lewis that we discussed yesterday. The other buildings are not suitable for fallout shelters, primarily because they do not have basement areas. The total money in the construction program for this purpose is $495,000; $395,000 of which is for the two Goddard facilities.

Mr. THOMAS. What about the Lewis facilities?

Mr. ULMER. $100,000; $50,000 apiece—$50,000 for the energy conversion laboratory and $50,000 for the basic materials research.

Mr. THOMAS. Did you request this?

Mr. ULMER. Those amounts are included in these estimates.

Mr. THOMAS. I asked you, did you request this?

Mr. ULMER. Not originally, sir, but we were later advised our estimates should be increased to include these amounts.

Mr. THOMAS. How many square feet will it cover?

Mr. ULMER. I cannot give you that. I would have to go back again to the drawings for those buildings. It is a function almost entirely of the basement areas provided in the buildings; in some cases they have full basements, and in some cases partial basements.

Mr. THOMAS. Will they serve any useful purpose in your day-to-day activities?

Dr. DRYDEN. No, sir. In many cases what it amounts to is some increase in the thickness of the walls in the basement, or something of that sort, which serves no function in the ordinary use of the building.

Mr. BOLAND. Are we doing this in all construction work now?

Mr. THOMAS. No.

Mr. BOLAND. I see.

UTILITY INSTALLATIONS

Mr. THOMAS. Let us take a look at the utility installations at the Goddard Space Flight Center. You say on page 342:

> This project covers the necessary additional utility installations required by the Goddard Center. The project includes the erection of a security fence and gatehouse, site and road improvements, utility extensions, and additions to the heating plant.

As well as I remember you are going to buy a little piece of land here.

Dr. DRYDEN. No land.

Mr. THOMAS. We shall insert pages 342 and 344 in the record at this point.

(The pages referred to follow:)

UTILITY INSTALLATIONS

1. Description

This project covers the necessary additional utility installations required by the Goddard Center. The project includes the erection of a security fence and gatehouse, site and road improvements, utility extensions, and additions to the

heating plant. The proposed work is indicated on the plot plan of the Goddard Center shown on the following page.

2. Justification

At the Goddard Space Flight Center, authorized in the fiscal year 1959, the NASA is establishing a development center from which space programs can be planned, monitored, controlled, and evaluated. In conjunction with the two additional buildings being proposed for construction in the fiscal year 1961, additional supporting utility installations will be required. The central power, steam generating, and refrigeration plants must be enlarged; extensions will have to be made to the underground utility distribution systems; site clearing and grading is required; additions will have to be made to site roads and parking areas; a property fence and gatehouse will have to be erected; and the installation of alarm and traffic control systems for security operations will be required.

In addition, the improvement of Glen Dale Road, currently a secondary county road, from the Baltimore-Washington Parkway to Telegraph Road is necessary. The Goddard Space Flight Center site occupies approximately two-thirds of this front footage on the north side of Glen Dale Road; a fair share of the estimated cost of improvement is approximately one-third. The required additional right-of-way for widening the road is available from Government property.

3. Cost estimate

Additions to the central heating plant	$480,000
Extension of power, water, and sewer utilities	220,000
Site work and roads	240,000
Improvement to county road	200,000
Boundary fence and clearing	82,000
Gatehouse, security, and traffic control equipment	87,000
Total estimated cost	1,309,000

4. Construction schedule

Total estimated completion time, 26 months.

Mr. THOMAS. You come up with a total figure of $1,309,000.

Why is it necessary to have an addition to your central heating plant at this time in the amount of $480,000? When was the plant constructed?

Dr. DRYDEN. The same problem is presented here as with the cafeteria. The two buildings first installed required heat. This was provided with a small heating installation. This provides for a central heating plant for the whole site.

Mr. THOMAS. Did you build your present heating plant?

Dr. DRYDEN. It was necessary to provide heat for the first two buildings.

Mr. THOMAS. Did you not plan your heating plant for later enlargement?

Dr. DRYDEN. Yes.

Mr. THOMAS. And what you are requesting is just an extension to the original unit?

Dr. DRYDEN. That is correct.

Mr. THOMAS. How firm are these estimates here? I see site work and roads, $240,000. You can do a lot of dirt moving for $240,000.

Dr. DRYDEN. Yes. That is shown on the plat plan.

Mr. THOMAS. I do not see much justification here.

You say on page 342 of the justification:

> The central power, steam generating, and refrigeration plants must be enlarged; extensions will have to be made to the underground utility distribution systems; site clearing and grading is required; additions will have to be made to site roads and parking areas; a property fence and gatehouse will have to be erected; and the installation of alarm and traffic control systems for security operations will be required.

Why the expenditure here of $87,000 for a gatehouse? What is the purpose of that?

Dr. DRYDEN. This is required to control the admission of visitors.

Mr. THOMAS. What kind of a fence are you going to put up?

Dr. SILVERSTEIN. One of the standard chain-link fences we use at our other laboratories.

Mr. JONAS. What will be the total construction investment at Goddard, including buildings under construction now, and the new ones—the physical plant?

Mr. ULMER. We had a 1959 program of approximately $4 million. There were three additional buildings and utility installations provided in the 1960 program totaling about $14 million. The 1960 program includes no additional buildings. The next increment we are talking about is $9.5 million in 1961.

Mr. JONAS. A total of how much?

Mr. ULMER. $9.5 million in this estimate.

Mr. JONAS. $27.5 million for construction to date. Was any consideration given to using existing facilities such as the Naval Gun Factory before this project was begun at Goddard?

Dr. DRYDEN. Very much so. There was a survey made of available buildings. These are not suitable for this purpose.

Mr. JONAS. Could it not have been modified?

Dr. DRYDEN. Not economically. We had one recent experience, as you may recall—Chincoteague. The naval air station was abandoned and turned over to us. It has a great variety of buildings. We did modify the original construction plant at Wallops, to use these buildings. We saved several million, but we did not save the full cost of the buildings because we had to make considerable alterations to provide the control station, the telemetry station for the Wallops Island installation. We did at the time examine specifically the Washington Navy yard facility. This was in 1958.

Mr. THOMAS. Chincoteague is a big naval base. The Navy must have put $200 million in it. It is only 10 miles from their Wallops station, but is was not close enough to the District of Columbia.

WALLOPS ISLAND STATION

OPERATIONS COMPUTING CENTER

The next item for consideration is the operations computing center at Wallops station.

We shall insert in the record pages 348 and 349 of the justifications.

(The pages referred to follow:)

OPERATIONS COMPUTING CENTER

1. Description

This project is requested to provide a center capable of handling data reduction at the Wallops station. The main computing machines will be rented, but it will be necessary to provide funds for (1) the purchase of auxiliary equipment such as film readers, strip chart readers, automatic data plotters, small desk-type calculators, and tape to card converter for telemetering data; and (2) remodeling part of an existing building at the Wallops station to house the rented computers and the related equipment.

2. Justification

Data from the Wallops station's firings are now reduced at the Langley Center and are, in general, handled in a manner tailored for aerodynamic research. By 1961, the volume of firings scheduled for the station (involving the Langley,

Goddard, Ames, and Lewis Centers, and many sounding rocket contractors) makes it essential that facilities be provided at Wallops station to reduce promptly to a tabulated form radar, rawinsonde, optical, and Doppler data. In addition, the ability to compute dispersion characteristics and impact predictions will increase the safety factor, reduce clearance areas, and aid in the recovery of some payloads.

3. Cost estimate

Equipment	$260,000
Automatic plotter	25,000
Strip chart and film readers	92,000
Telemeter tape to card converter	80,000
Doppler chronograph	50,000
Miscellaneous equipment	13,000
Air conditioning	60,000
Building modification	30,000
Total estimated cost	350,000

4. Construction schedule

Total estimated completion time, 10 months.

Mr. THOMAS. How does this overlap with the Goddard computing center and your others? I believe you stated yesterday you have these computing centers and they are all necessary on their own; is that correct?

Dr. DRYDEN. Yes. As you see, this project covers $350,000 for the equipment needed in connection with the direct-range operations. I believe it was mentioned yesterday that one of the computations that has to be made very quickly is the effect of the wind. A sounding balloon is sent up to measure the upper air winds and the trajectory has to be adjusted for the cross winds so that the instrument lands in a safe area and does not come down near ships or airplanes.

EQUIPMENT MODERNIZATION

Mr. THOMAS. Here is another item for Wallops Island, a new launcher. We will insert pages 350, 351, and 352 in the record at this point.

(The pages referred to follow:)

EQUIPMENT MODERNIZATION

1. Description

An improvement in the technical capabilities of the Wallops Station is required in three equipment areas, as follows:

Vehicle checkout equipment.—This portion of the project covers the procurement of equipment required in the testing of vehicles and their components prior to launching. The project includes the procurement of microwaves and VHF antenna pattern systems for radar beacon, telemeter, and destruct antenna measurements; the procurement of environmental test and checkout equipment for vehicles and their associated components; and the construction and outfitting of two shielded telemeter checkout rooms in existing buildings.

Radio-frequency monitoring equipment.—Equipment is required to monitor, measure, and locate radio-frequency interference in the Wallops Station area. The equipment will consist of field strength and frequency meter covering a frequency range from 30 cycles to 1,000 megacycles with recorders and fixed stations and van-type installations. Spectrum analyzers will be employed to cover a frequency range from 10 to 44,000 megacycles to allow spectral observations of pulse signal characteristics, frequency modulation identification, and the comparison of two radio-frequency signals having similar frequency separation. Servo-operated directional antennas will be used to locate interference sources.

Launching and handling equipment.—Additional equipment is required to prepare, transport, position, and launch the larger research vehicles which will

be operational in 1961. The project includes a launcher and associated cabling, two umbilical towers, and mobile handling equipment.

2. *Justification*

Existing facilities at the Wallops Station were planned on the basis that all preliminary checkout, environmental tests, and antenna pattern measurements would be performed before the vehicle arrived at the Wallops Station for firing. Current planning, however, indicates that in several program areas vehicles will be shipped directly from contractors to the Wallops Station with payloads built by outside scientific groups who could not be expected to provide checkout facilities. It is necessary that provisions be made to properly test these vehicles and payloads.

The number and variety of firings scheduled for the Wallops Station will inevitably result in radiofrequency interference. To prevent the loss of data or delays in firings resulting from such interference, equipment must be provided to pinpoint the source and characteristics of radiation interfering with electronic systems utilized for communications, launching, tracking, and data relaying functions. Monitoring of specific frequency bands is necessary to establish clear channels and to determine whether the Wallops Station's operational frequency assignments and schedules are maintained within the specified limitations.

The larger research vehicles scheduled for launching from Wallops Island by 1961 will require additional equipment and facilities. The increase in size alone of the vehicles necessitates higher capacity handling equipment. Where possible, equipment will be secured that can be used for different-size stages. In some cases, equipment will have to be designed especially for a particular vehicle.

Since the setup and checkout time in the launching area for a large research vehicle can run into weeks, the single Scout launcher will not be adequate for the Wallops Station schedule by 1962. An additional launcher of comparable size and capability will be needed for research vehicles using the larger rocket motors now available and under development.

Recent developments have proven the need for umbilical towers to adequately handle and program the missile cable requirements during a countdown. The towers are not only necessary to properly handle the operation but are a vital necessity for adequate pad safety.

Wallops will be scheduling more launchings during the hours of darkness. This is a requirement of many scientific experiments and is also dictated at times by range availability on long-range launches. An adequate night lighting system is a necessity for safe night operation.

3. *Cost estimate*

Vehicle checkout equipment	$800,000
Antenna pattern systems	90,000
Reliability test equipment	290,000
Telemeter checkroom equipment	50,000
Beacon test equipment	25,000
Destruct receiver test equipment	15,000
Airframe and rocket inspection, alinement, and radiograph equipment	200,000
Construction of shielded telemeter checkrooms	130,000
Radiofrequency monitoring equipment	130,000
Launching and handling equipment	840,000
Launcher	308,000
Power and control cable	95,000
Night lighting equipment	105,000
Positioning trailers and adaptors	156,000
Tug	8,000
Transportation trailers	11,000
Missile manipulator	75,000
Umbilical towers	82,000
Total estimated cost	1,740,000

4. *Construction schedule*

Total estimated completion time, 12 months.

Mr. THOMAS. The total cost for equipment modernization is $1,740,000. You say on page 350,

> An improvement in the technical capabilities of the Wallops Station is required in three equipment areas, as follows.

And then you list vehicle checkout equipment, radio-frequency monitoring equipment and launching and handling equipment.

You say at the bottom of the page,

> Existing facilities at the Wallops Station were planned on the basis that all preliminary checkout, environmental tests, and antenna pattern measurements would be performed before the vehicle arrived at the Wallops Station for firing. Current planning, however, indicates that in several program areas vehicles will be shipped directly from the contractors to the Wallops Station with payloads built by outside scientific groups who could not be expected to provide checkout facilities. It is necessary that provisions be made to properly test these vehicles and payloads.

You have the same facility at Goddard also, do you not?

Dr. DRYDEN. No. This is the flight checkout, the same sort of thing done at Canaveral a few days before they fire a satellite. This refers to the checks made immediately before firing to see that everything is operating properly.

Checks at Goddard are ones of durability; whether they will stand the vibration, temperature, and cold.

Mr. THOMAS. You have some 15 items composing the $1,740,000.

What is positioning trailers and adaptors in the amount of $156,000?

Dr. DRYDEN. The larger rockets cannot be handled by hand but usually require a special trailer vehicle adapted to the particular missile. Wallops Island, of course, is doing on a small scale what you may have observed at Canaveral where they use enormous trucks.

Mr. THOMAS. These trailers are nothing but a bunch of welded pipes on wheels.

Dr. SILVERSTEIN. There will be two when we finish this purchase. We have one now.

Mr. THOMAS. Where are these made? Are they fabricated in your shops?

Dr. SILVERSTEIN. They are purchased.

Mr. THOMAS. Do you have a firm price on them?

Dr. SILVERSTEIN. I think we probably have a fairly good price for the one we have. This is for the bigger vehicles like Scout. It goes along with the additional launcher.

Mr. THOMAS. Are they 75 feet to 100 feet long?

Dr. SILVERSTEIN. I would guess around 100 feet long just from looking at them—80 to 100 feet.

Mr. THOMAS. The design is quite simple. The configuration is to fit the bird?

Dr. SILVERSTEIN. Yes, but the vehicle includes erection equipment.

Mr. THOMAS. How do you arrive at this figure of $308,000 for your launcher?

Dr. SILVERSTEIN. We have one and this is a second. I think it is probably based on previous costs.

Mr. THOMAS. Was it built by your own laboratory on site?
Dr. SILVERSTEIN. No, sir, under contract.
Dr. DRYDEN. It was built by Chance Vought in Texas.

JET PROPULSION LABORATORY

SALARIES AND EXPENSES

Mr. THOMAS. We will now take up the Jet Propulsion Laboratory. Were you able to bring up the table for salaries and expenses for the laboratory?

Mr. ULMER. This table I have here indicates in 1961 JPL will be getting $62.6 million as their total budget; $59.3 million coming from NASA and $3.3 million from Army Ordnance. Of that $62.6 million, approximately $27 million covers salaries and some of the S. & E. costs we have been talking about.

Mr. THOMAS. What is your total cost for JPL in 1959, 1960 and 1961? You have a figure here of $57,633,000 for 1959; $57,468,000 for 1960 and $62,600,000 for 1961.

Dr. DRYDEN. That includes both NASA and Army costs.

Mr. THOMAS. Is this all salaries and expenses?

Mr. ULMER. No, it includes R. & D. funds, all moneys being put into JPL by NASA and Army Ordnance, except construction funds.

Mr. THOMAS. Where are your other objects?

Mr. ULMER. They are included in the figures I mentioned previously, Mr. Thomas.

Mr. THOMAS. What do your other objects comprise?

Mr. ULMER. Travel costs, retirement benefits, overtime, printing, communications, and that type of thing.

Mr. THOMAS. Certainly you will not have other object costs of $16 million against a salary cost of $19,500,000?

Mr. ULMER. No. The $16 million is approximately equivalent to the 07, 08, and 09 costs under the "Research and development" appropriation in our budget.

Mr. THOMAS. Where is the breakdown on that? What yardstick do you use? Who is your contractor?

Dr. DRYDEN. California Institute of Technology is the contractor. They operate the Jet Propulsion Laboratory. They do not, of course, carry on their bookkeeping identical with Government bookkeeping. What has been attempted here is to show you the cost of the equivalent items.

Mr. THOMAS. Do they have any limitations on pay schedules? Do they go by Government standards?

Dr. DRYDEN. We have had our personnel division review the pay scales at JPL. With the exception of the few top positions which are well above Government pay scales, the general standard is fairly equivalent. The main difference is that their ceiling is higher.

Mr. THOMAS. There is no secret about this matter. We have asked you three times for some information on it and we have not gotten it yet. Can we expect it?

Dr. DRYDEN. This is the breakdown that you have asked for.

Mr. THOMAS. This breakdown is just about as clear as the fog outside. Does it include your construction money?

Dr. DRYDEN. No, sir.

Mr. THOMAS. That is in addition to this $62,600,000, is it not?

Mr. ULMER. Right.

Mr. THOMAS. I hope you will take another try at it.

Dr. DRYDEN. It is impossible to break it down in exactly the same way as the Government does. This is a contractor who has a system of bookkeeping that is different.

Mr. THOMAS. You are spending the taxpayers' money, and we would like to know something about it.

Dr. DRYDEN. So it is on any contract. I do not know that it has been the practice to try to get this kind of a breakdown for contractors. We will try to get the information in as comparable form as possible. If there are specific items we will dig them out.

Mr. THOMAS. Why is this a contract when you operate the other installations directly.

Dr. DRYDEN. Because the JPL is a private organization operated by the California Institute of Technology. This group is the one which carried out the first satellite program in the United States as a contractor of the Army.

Mr. THOMAS. Is this a private corporation?

Dr. DRYDEN. A private corporation. A university is the contractor.

Mr. THOMAS. We would like to know exactly your yardstick. You say it is costing this year $62,600,000, and that is an inconclusive figure. You have another $10 million or $12 million to add to it for construction.

Dr. DRYDEN. This was set forth separately. You asked for the additional figures. We have the breakdown by salaries and other objects.

Mr. THOMAS. Who gets the title to the property?

Dr. DRYDEN. The property is owned by the Government. It is operated by the contractor. It is the same system used by the Army for 15 years. We have not changed the method of operation at all.

Now the alternative that faced the new space agency was to disregard a group that had operated for 15 years, that was responsible for the first satellite built and put in orbit and say—we will not work under that system, we will organize a new laboratory.

Mr. THOMAS. We are not arguing with you. All we want is a complete breakdown of the amount of money you are spending at the institution. If it is not a secret, we would like to have it.

Dr. DRYDEN. It is not a secret. We can get a financial report from JPL.

Mr. THOMAS. All right. This is the fourth time we have asked for it.

(The information requested follows:)

JET PROPULSION LABORATORY

(Operated under NASA R. & D. Contract Nasw–6 with the California Institute of Technology, funded from the NASA research and development appropriation.)

Analysis of JPL obligations in terms of NASA S. & E. and R. & D. appropriation classifications

	Fiscal year 1959, commitments	Fiscal year 1960, estimated	Fiscal year 1961, estimated
I. SALARIES AND EXPENSES, TYPE COMMITMENTS			
Personal services:			
Number of full-time employees (end of year)	2,680	2,660	2,400
Average number of full-time employees	2,399	2,635	2,488
Annual cost:			
Full-time employees	$14,603,962	$18,425,300	$20,792,400
Intermittent employment	221,900	254,450	292,600
Overtime	1,729,715	2,399,250	1,665,000
Other allowances	165,115	221,000	250,000
Total personal services	16,720,692	21,300,000	23,000,000
Travel	909,579	1,000,000	1,150,000
Transportation of things	31,650	83,000	100,000
Communications	287,774	230,000	230,000
Rents and utilities:			
Electric power	366,311	480,000	580,000
Other utilities	59,221	59,000	59,000
Rentals	556,501	814,600	796,600
Printing and reproduction	137,496	240,000	240,000
Other contractual services	249,114	335,000	310,000
Taxes and assessments (FICA)	269,391	280,000	320,000
Total salaries and expenses, type commitments	19,587,729	24,821,600	26,785,600
II. RESEARCH AND DEVELOPMENT ALLOCATIONS			
Support of plant	1,495,426	1,797,000	1,845,000
Direct program charges	36,549,445	30,849,400	33,969,400
Total research and development	38,044,871	32,646,400	35,814,400
JPL total operating budget	57,632,600	57,468,000	62,600,000
Funding by source:			
National Aeronautics and Space Administration	19,886,500	37,968,000	59,300,000
Army Ordnance and others	37,746,100	19,500,000	3,300,000
Total funding	57,632,600	57,468,000	62,600,000

LAND ACQUISITION

You have a piece of land here. We will insert page 354 of the justifications in the record at this point.

(The page referred to follows:)

LAND ACQUISITION

1. Description

This project proposes the acquisition of 3.4 acres of privately owned land contiguous to the southwesterly boundary of the laboratory. The area is identified as zone IV in the site plan on the preceding page.

2. Justification

The only other privately owned contiguous site is being rapidly developed and there is every reason to believe that zone IV will also undergo similar development unless the site is acquired. If this should happen, it will become almost impossible for the laboratory to extend its present area without excessive and prohibitive cost. Inasmuch as this area is the only privately owned land between the existing laboratory and the land owned by the city of Pasadena, its acquisition is considered to be a prudent and economical investment. It is proposed to locate the publications, library, and technical services building (funds for which are being requested in these estimates) in zone IV as indicated on the site plan.

3. Cost estimate

Total estimated cost, $60,000.

Mr. THOMAS. Your justifications indicate that the cost may go up in the future and in the future you may need it and therefore you better buy it now.

Dr. DRYDEN. I would say that the conditions on the site are very crowded. It cannot be expended beyond this 3.4 acres at any time.

Mr. THOMAS. You picked a bad site to start with.

Dr. DRYDEN. The site has been there for 15 years. It has an operating laboratory and an operating organization. We could not lift it up and move it without an expense that would be very prohibitive.

MODERNIZATION OF LABORATORY FACILITIES

Mr. THOMAS. We will take up modernization of laboratory facilities and insert pages 355, 358, and 363 in the record at this point. Also pages 365, 366, and 367.

(The pages referred to follow:)

MODERNIZATION OF LABORATORY FACILITIES

1. Description

This project proposes the modernization of a number of facilities to provide more effective and efficient laboratories and supporting facilities. Brief descriptions and drawings of the proposed work follow:

Space sciences laboratory.—It is proposed to construct a two-story frame and stucco building of approximately 16,000 square feet to house laboratories and offices for personnel who will be associated with the new Space Sciences Division. In addition to the office space for technical and administrative personnel, the building will provide laboratories for environment testing and for electronics and physics research and precision model shops.

Addition to environmental test laboratory.—In the designing of space vehicles it is essential that an environmental test laboratory be available where conditions of outer space can be duplicated and where various components of the vehicles can be tested under these conditions. This project proposes the construction of a 5,000-square-foot addition to the environmental laboratory. The addition will contain offices for the technical and supporting personnel, and laboratories to house the following equipment:

(*a*) Ultra-high-vacuum system for the simulation of space environments and the testing of guidance, propulsion, and communication system component parts.

(*b*) An equalization noise chamber for the investigation of the effects of acoustical noise on vehicle structures, payloads, and guidance equipment during the launch phase.

(*c*) A control system for the automatic equalization of the random frequency vibration electromechanical exciter system now in use.

(*d*) A test chamber in which the temperature can be varied from —100° F. to +300° F. with the provision necessary to facilitate vibration testing inside the chamber.

Addition to engineering mechanics and design building.—This project proposes a one-story 8,000-square-foot addition to the existing engineering mechanics and design building. The addition will consist of a large briefing or conference room capable of accommodating approximately 500 persons, plus 2 smaller seminar rooms, restrooms, and a utility room.

Materials research and processing facility.—The construction of two laboratory buildings is proposed to provide the facilities required to carry out supporting research and advanced development work on materials for space vehicles. The research laboratory building will contain approximately 10,000 square feet and will be designed to house precision equipment of the type needed to study the behavior of materials at extremely high temperatures, such as those encountered in rockets and under conditions of outer-space environment. The building will also contain offices for technical and supporting personnel. The processing laboratory will contain approximately 5,400 square feet and will be designed to house some of the fabrication and processing equipment needed to develop and test materials for space-vehicle applications. Approximately 1,000 square feet will be assigned for chemical propulsion research and development.

Publications, library, and technical services building.—This project proposes the construction of a 17,000-square-foot two-story building to house administrative groups. This building will contain the main library, the reproduction department (blue-printing machines, printing presses, etc.), a vault, a TWX room, a central documents control room, a document film room, a photo department, editorial offices for the technical reports group, and general administrative offices.

Addition to fabrication services building.—This project proposes a 10,000-square-foot addition to the present fabrication services building. It will be of frame and stucco construction. It will be a two-story building with the lower floor devoted to heavy machine shop equipment, a tool crib, a precision instrument and optical shop, and an optical precision assembly room. The second floor will contain the fabrication services offices, restrooms, locker room, inspection and bond room, light machine equipment room, tool crib, precision grinding room, stock-control room, and small room for storage of lightweight materials.

Addition to administrative services building.—An 8,000-square-foot third-floor addition to the present administrative services building is requred. The addition will contain offices and restrooms and will provide additional work space for the purchasing, accounting, IBM, shipping, receiving, and property departments.

2. Justification

In general, the programs at the Jet Propulsion Laboratory have changed over a period of years. Since Sputnik I was launched, the laboratory has had a greatly expanded mission and has become involved in space probes. Under NASA, its mission has been concerned with lunar shots, and with guidance and communication systems. Its personnel growth has been rapid, and suitable buildings have not been constructed to keep pace with the increase in personnel. It has been necessary, therefore, to modernize existing facilities. In order to efficiently carry out the NASA programs it is necessary to continue the modernization program, to add general purpose and specialized facilities, and to regroup functions into efficient working entities.

Space sciences laboratory.—The conduct of the national space flight program by the NASA requires that the laboratory establish a Space Sciences Division, which will maintain close technical liaison with scientists and engineers at other NASA laboratories and research centers. A number of the payload elements carried aboard vehicles developed under the technical direction of the laboratory may be parts of experiments sponsored by other organizations and built else-

where. This division will have the responsibility for insuring that the construction of the payload elements meets flight criteria and that the equipment is properly integrated into the vehicle payload and the overall scientific mission. In order to carry out these objectives it is necessary to have this entire Division in one building with the proper provision for offices and laboratories.

The Division is intended to function at the international level in the conduct of its work. This means that the Division will always have working a number of foreign scientists who have not yet received security clearances. This is the basic reason for locating the proposed building outside the laboratory security fence.

Addition to environmental test laboratory.—The reliability program of the laboratory is based on the philosophy of designing and testing to a verified safety margin. This can only be accomplished by means of comprehensive and integrated laboratory testing and use test techniques wherein equipment can be shown to operate satisfactorily under environmental conditions, both natural and induced, at levels significantly in excess of those expected in actual flight use. To accomplish this, all critical environments must be simulated in the laboratory by the use of specially designed and constructed equipment and facilities. The laboratory has in the past maintained a leading position in the development of environmental design for typical guided missile environments and must now extend this capability to include the simulation of those conditions expected in deep space flight.

Addition to engineering mechanics and design building.—In connection with its role in NASA projects, the laboratory's work involves numerous conferences with NASA personnel, contractors, and subcontractors, and representatives of the national and international scientific community. Facilities are required for a large conference or briefing room in which to hold meetings of up to 500 persons.

Materials research and processing facility.—The materials research and processing laboratories will be used to house the present equipment and also equipment for NASA-approved programs. This group has a great need for adequate housing in both offices and laboratories. These groups have had no increase in work space for the last 6 or 7 years.

Performance of existing vehicles is limited by the lack of knowledge of the properties of materials at very high temperatures. Laboratories are needed to permit study of the mechanical, thermal, and gas reaction properties of many different materials at 3500° to 6000° F. or higher. The approach to a solution of these problems will be from the standpoint of metallurgy and ceramics and also from that of solid state physics. Development and testing of improved materials will be carried out on many types of space-vehicle components. These will include rocket nozzles and other propulsion components, fuel tanks, and solid fuel rocket cases, and equipment to operate in the very high vacuum of outer space. Part of the work will be aimed at providing engineering data required to design advanced types of space vehicles.

Some of the present limitations in space vehicle systems concern guidance and communications. It is planned to work in the new laboratories toward the development of solid state electronic devices which will permit considerable increases in sensitivity and range, together with major decreases in weight and size of space vehicle electronic devices and instruments for lunar and interplanetary space exploration.

Publications, library, and technical services building.—This building is urgently needed to provide more space for the reports group and for related activities such as the reproduction photo departments.

Addition to fabrication services building.—The present fabrication services building is inadequate in size for the volume and variety of work that it must perform. The proposed new addition will also eliminate the air-conditioning problem that we encounter in the present building. No shop area has been added to this building since 1953 in spite of an increased demand from the engineering design section for high precision work.

Addition to administrative services building.—In the present administrative services building the personnel in the Accounting and Purchasing Department are provided with only 35 to 40 square feet per person; this is far below any accepted standards. The operations are at present scattered in several buildings and the new addition will permit the consolidation of all related groups into one building.

3. Cost estimate

Space sciences laboratory		$500,000
Building	$360,000	
Utilities	40,000	
Electronic equipment	50,000	
Chemical equipment	50,000	
Addition to environmental test laboratory		250,000
Building	$135,000	
Utilities	15,000	
Ultra high vacuum test chamber	50,000	
Acoustical test chamber	25,000	
Temperature test chamber	25,000	
Addition to engineering mechanics and design building		200,000
Building	$170,000	
Utilities	20,000	
Audio and visual equipment	10,000	
Materials research and processing facility		500,000
Building	$405,000	
Utilities	45,000	
Research equipment	50,000	
Publications, library, and technical services building		435,300
Building	$360,000	
Utilities	40,000	
Equipment	35,300	
Addition to fabrication services building		250,000
Building	$175,000	
Utilities	25,000	
Machine tools	50,000	
Addition to administrative services building		200,000
Building	$160,000	
Utilities	20,000	
Equipment	20,000	
Total estimated cost		2,335,300

4. Construction schedule

Total estimated completion time, 16 months.

Mr. THOMAS. You say on page 363:

The conduct of the national space flight program by the NASA requires that the laboratory establish a space sciences division which will maintain close technical liaison with scientists and engineers at other NASA laboratories and research centers. A number of the payload elements carried aboard vehicles developed under the technical direction of the laboratory may be parts of experiments sponsored by other organizations and built elsewhere. This Division will have the responsibility for insuring that the construction of the payload elements meets flight criteria and that the equipment is properly integrated into the vehicle payload and the overall scientific mission. In order to carry out these objectives it is necessary to have this entire Division in one building with the proper provision for offices and laboratories.

What is this building going to cost?

Dr. DRYDEN. $500,000.

Mr. THOMAS. How large is it going to be? How many square feet?

Dr. DRYDEN. 16,000 square feet; $22.50 per square foot.

Mr. THOMAS. What will it have?

Dr. DRYDEN. The building itself is $360,000, which when divided by 16 gives $22.50. There is $40,000 for utilities; $50,000 for electronic equipment; $50,000 for chemical equipment in the building.

Mr. THOMAS. Will there be anything here besides the laboratory? Will there be a cafeteria?

Dr. DRYDEN. Nothing of the kind.

Mr. THOMAS. What about a library?

Dr. DRYDEN. The library is shown as one large room.

Mr. THOMAS. How much is this building going to cost?

Dr. DRYDEN. $360,000 at $22.50 per square foot. The cost of buildings in California is considerably less than elsewhere because of the climatic conditions.

Mr. THOMAS. How much is the building a square foot?

Dr. DRYDEN. $22.50.

Mr. THOMAS. How many square feet?

Dr. DRYDEN. 16,000.

Mr. THOMAS. How necessary is this?

Dr. DRYDEN. I am sorry we took back the photograph of the site. I think if you looked at the site and the way it has been developed you would see the necessity of doing some rearrangement of things generally. This brings together activities that are scattered all over the whole reservation.

Mr. THOMAS. Addition to engineering, mechanics, and design building, $200,000. The building cost is $170,000.

Dr. DRYDEN. 8,000 square feet, $22 per square foot.

Mr. THOMAS. Utilities, $20,000. This is just an addition to an existing building?

Dr. DRYDEN. That is correct.

Mr. THOMAS. What will be the type of construction here—brick?

Dr. DRYDEN. No.

Mr. THOMAS. Reinforced concrete and steel, or what?

Dr. DRYDEN. Frame and stucco.

Mr. RHODES. How much a square foot?

Mr. THOMAS. $22.

Mr. RHODES. For frame and stucco? What else do you put in it, gold?

Dr. DRYDEN. No.

Mr. RHODES. Mr. Chairman, really, I do not know too much about construction in the western part of the United States, but that is awfully high for a frame-and-stucco job.

Mr. JONAS. That is the cheapest building in the program.

Mr. RHODES. The doctor said that you could build buildings cheaper in California. I think you can, but I think you can build them cheaper than $22 a square foot.

Mr. HORNER. Most of these buildings have some heavy equipment in them. The frame is steel, and the floors have to be stressed. They run higher than the normal frame and stucco structure that is used for a residence, and light industry.

Mr. THOMAS. That is only in your floors, though.

Mr. HORNER. Usually also in the roofs.

Mr. THOMAS. What about your materials and research processing facility, $500,000. You have a building here, $405,000. How much is it a square foot?

Dr. DRYDEN. 15,400 square feet at $26.25 per square foot.

Mr. THOMAS. You also have utilities at $45,000 and research equipment at $50,000.

What type of equipment is this?

Dr. DRYDEN. I am not myself familiar with this.

Dr. SILVERSTEIN. It is some of the small processing equipment used in handling materials—the rollers, dies, and test machines.

Mr. THOMAS. Here is an addition to your administrative service building in the amount of $160,000.

How many square feet are involved in this building?

Mr. ULMER. 8,000 square feet at $20 per square foot.

DESIGN AND CONSTRUCTION PROCEDURES

Mr. RHODES. Mr. Chairman, have we determined whether these buildings are built according to competitive prices or competitive bids or whether they are negotiated bids?

Dr. DRYDEN. Yes, sir; they are on a competitive basis. I think these are handled through the Corps of Engineers.

Mr. HORNER. Most of the construction at this laboratory has been handled by the Corps of Engineers.

Mr. BOLAND. How often do you utilize either the Corps of Engineers or the Bureau of Yards and Docks for assistance in this construction field?

Dr. DRYDEN. In this particular case this was an Army laboratory on which the construction was done by the Corps of Engineers and that method has been continued in the transition period.

Mr. BOLAND. What is the situation with reference to some of the new construction?

Dr. DRYDEN. With reference to the new construction in the last year or two, many of these items were in the Army development programs for the facility.

Mr. BOLAND. And they have continued to utilize the construction agency of the Army?

Dr. DRYDEN. Yes, sir.

Mr. THOMAS. Who developed these cost figures?

Dr. DRYDEN. They were developed at the JPL. We can ask Dr. Pickering specifically this afternoon about that. I am not sure whether the Corps of Engineers did all of it.

Mr. HORNER. The selection of the construction agency is dependent upon the location of the construction.

Mr. THOMAS. This is an exception to the rule, where you use the Corps of Engineers to do your construction, and the reason you do it here was because this was a takeover from the Army?

Mr. HORNER. This has also been the practice, Mr. Chairman, at the Atlantic Missile Range where we have some $26 million worth of construction, and at Huntsville.

Dr. DRYDEN. In the past we have used the Corps of Engineers, but we have not made a commitment that we will always use them in the construction that is shown on this chart.

Mr. BOLAND. Would it not be wise to use one of the construction agencies of the Federal Government? Do you not think it would be a wise idea to do that?

Dr. DRYDEN. We have found in the past over long years that they are very useful in building the ordinary type of construction. In the construction of wind tunnels and other special equipment we have found it much more advantageous and much less expensive to do it with ourselves, so to speak, as the general contractor. It is because we have on our staff the people with experience and background in this specialized construction. So, I would say that in the case of nonspecialized construction we have used them and in the case of specialized construction we have not. Some of the facilities here are ordinary buildings and others are specialized facilities.

Mr. SIEPERT. Might I add this? There are exceptions to this. The Corps of Engineers of the Army has acquired probably the best competence in the country in terms of supervising the construction of the sort that goes into launching pads and the like, and in that kind of situation we would deal completely with the Corps of Engineers. Our understanding with them is that we would deal with them in the areas of their competence, but the only thing we reserve is to be sure that we are getting the best deal we can from them, because we are not their priority customers. As long as they can actually give us the kind of service we want at a reasonable cost and within an assured time schedule, we are happy to deal with them.

Mr. THOMAS. Where do your overall construction people come into the picture? You farm some of this out to the Corps of Engineers and some is done on competitive bids.

Where does this overall contractor come in?

Mr. SIEPERT. Competitive bidding is used in all cases. The people on our staff are the ones who say what we want. They do what you might call the kind of directing you see here as to what kind of building we need and how much space and what kind of laboratories we would need, and then we will proceed from this to a competitive bid contract and our people will be used as inspectors. This is the function of the construction people on our staff which programs the engineering of the many things connected with our test activities.

Mr. THOMAS. Where does your general contractor fit into the picture?

Mr. SIEPERT. The general contractor does the detailed plans in cases where there is not a separate architect-engineer, and he completes the detailed plans approval and then he carries out the construction.

Mr. THOMAS. Does he have the absolute say as to the method of construction? By that I mean, whether he lets this out on competitive bid or whether he checks the subcontractors, or just how does he function?

Mr. SIEPERT. The general contractor is a man who submits the competitive bid and it will be based, of course, on the subcontracting system.

Mr. THOMAS. What do you mean when you say he submits it?

Mr. SIEPERT. He submits it to NASA.

Mr. THOMAS. You first go to your general contractor and say you want Projects A, B, C, D, and E?

Mr. SIEPERT. That is right.

Mr. THOMAS. That is, at a certain time?

Mr. SIEPERT. Yes, sir; and then we have the general specifications.

Mr. THOMAS. What does he do from there on?

Mr. HORNER. We do not usually hire the general contractor for more than one facility, Mr. Chairman. The general contractor is selected by competitive bid. In the process of selection the determination is made as to the degree of responsibility he bears in selecting subcontractors for utility installations in this kind of thing.

Mr. THOMAS. Does he have the absolute say with reference to the subcontractors?

Mr. HORNER. No, sir.

Mr. THOMAS. Does he do it for you?

Mr. HORNER. The subcontractors have to be approved by NASA.

Dr. DRYDEN. The normal case in a major project, certainly, is to have an architectural engineer under a separate contract to prepare the detailed drawings and specifications which you put out for competitive bids to general contractors. This is the normal case.

Mr. THOMAS. We attempted to go into your tracking system yesterday and you were not able to tell us anything about it.

Dr. DRYDEN. That was not a normal construction contract. It was primarily radar equipment with a few small buildings thrown in; it includes site preparation in countries all over the world.

Mr. THOMAS. When we get to it, are you prepared to give us a detailed breakdown on it? You were not able to do that yesterday.

Dr. DRYDEN. Again, we can give you all of the contract documents.

Mr. THOMAS. In the first place, you did not know how many stations you had even in the United States and who your contractor was as well as what yardstick you used to pay him.

Dr. DRYDEN. This is being prepared?

Mr. BOLAND. How much of a construction branch do you have? How many people are in your construction branch in NASA?

Dr. DRYDEN. We could go to the staff charts. It is shown on the laboratory staff.

Mr. ULMER. Each laboratory has a construction staff which performs not only this work but the regular work involved in minor construction and in modifying facilities to meet research program requirements.

Mr. BOLAND. This is the fixed plant?

Mr. ULMER. Yes. The same group does both jobs. They do the engineering where a minor construction project is involved or where a major one is involved. I would say a rough guess would be 70 or 80 people at a major installation.

Mr. HORNER. We have at the headquarters one facility staff man who is responsible for coordinating our facilities program.

Mr. BOLAND. He has quite a job.

Mr. HORNER. He does not get involved in the details.

Mr. THOMAS. He is just a policy man.

SOLID PROPELLANT FACILITY

Mr. THOMAS. At this point in the record we shall insert pages 368, 370, 371, and 372 of the justifications.

(The pages referred to follow:)

SOLID PROPELLANT FACILITY

Description

It is proposed that a complex of buildings be constructed to house the solid propellant rockets and solid propellant chemistry sections. The buildings will be

designed to process hazardous materials in quantities the laboratory cannot process in its present installations. All buildings will be designed to operate remotely, if necessary, keeping the safety of the personnel foremost.

Oxidizer process buildings will be arranged to blend, dry, and grind hazardous materials in a safe and efficient manner. Included in this complex are remote controled propellant mixing and casting buildings which will be designed and geographically located so as to be in accordance with ordnance safety manual requirements. The completed solid propellant will be processed in a remotely controlled preparation building and subsequently transported to storage bays for conditioning before static firing. Also included are a group of hazardous storage magazines with a capacity great enough to accommodate a reasonable propellant development program. A solid propellant process laboratory will be constructed to test physical properties, burning rates, analyze oxidizer particle size, impact sensitivity, and auto ignition of new propellants. Staff labs, chemistry labs, and shops will be provided to support the varied activities of this building.

The plot plan on the following page indicates the location of the buildings proposed for construction under this project.

Cure building.—The cure building will consist of one building with three earth-covered reinforced concrete cells, providing controlled temperature from ambient to 200° F. for curing and conditioning solid propellants.

Storage and conditioning magazines.—This building will consist of one building with 27 earth-covered reinforced concrete cells to provide controlled temperatures from —80° to +200° F. for the storage and conditioning of solid propellants.

Blender and drying buildings.—Five separate buildings will be constructed. Three will house different types of oxidizer grinders, one will house blender dryer equipment to process oxidizers, and the fifth will house the control center from which all operations will be conducted remotely.

Storage and conditioning building.—This building will contain nine earth-covered reinforced concrete cells and will provide controlled temperature from ambient to 200° F. for the storage and conditioning of solid propellants.

Mixer buildings.—A total of five buildings will be constructed; three will contain three bays with 200 pounds capacity each. The fourth building, a casting bay, will service all mix bays. The fifth building will contain a control center from which all operations will be conducted remotely.

Charge preparation buildings.—Three separate buildings for the preparation of completed solid propellent charges will be provided. One building will provide an area for X-ray and visual inspection of solid propellent charges; the second building will provide space for the preparation of completed solid propellent charges; and the third building will house a lathe, mill, reamer, and vacuum recovery system for machining solid propellent charges.

2. *Justification*

The jet propulsion laboratory was established before safety codes dealing with solid rocket propellents were available. Subsequent safety code standards have made most of the solid rocket test facilities at the laboratory nonconforming. At the present time, all but 20 of the 100 facilities on the laboratory site are operating under waivers. These waivers make it impossible to modify any existing facilities to meet the changing program needs and thus severely restrict the potential growth of the solid propellent effort at the laboratory. The recently acquired 60-acre site has now permitted the relocation of several solid propellent facilities and associated equipment to a location where required safety code standards can be met. This project provides further relocation of additional solid propellent facilities.

3. Cost estimate

Cure building	$85,000
Building	44,800
Utilities	37,500
Instrumentation and controls	2,700
Storage and conditioning magazines	571,600
Buildings	360,000
Utilities and barracades	141,600
Instrumentation and controls	70,000
Blender and drying buildings	100,000
Buildings	39,500
Utilities	32,500
Barricades	28,000
Storage and conditioning building	90,800
Building	44,800
Utilities	37,500
Instrumentation and control	8,500
Mixer buildings	260,000
Buildings	190,000
Utilities	30,000
Barricades	40,000
Charge preparation buildings	258,800
Buildings	171,700
Utilities	19,000
Barricades	20,000
Instrumentation and control	48,100
Site utilities	588,500
Site preparation	153,500
Chilled water lines	50,000
Hot water lines	50,000
Utility trenches	65,000
Compressed air system	5,000
Sewer system	10,000
Water system	15,000
Gas system	10,000
Power distribution and transformers	130,000
Erosion control	50,000
Drainage system	25,000
Paving	25,000
Total estimated cost	1,954,700

4. Construction schedule

Total estimated completion time, 16 months.

Mr. THOMAS. This still has to do with the JPL laboratory. This is the solid propellant facility. Your justifications state:

It is proposed that a complex of buildings be constructed to house the solid propellent rockets and solid propellent chemistry sections. The buildings will be designed to process hazardous materials in quantities the laboratory cannot process in its present installations. All buildings will be designed to operate remotely, if necessary, keeping the safety of the personnel foremost.

A solid propellent process laboratory will be constructed to test physical properties, burning rates, analyze oxidizer particle size, impact sensitivity, and autoignition of new propellants. Staffs labs, chemistry labs, and shops will be provided to support the varied activities of this building.

The jet propulsion laboratory was established before safety codes dealing with solid rocket propellants were available. Subsequent safety code standards have not made most of the solid rocket test facilities at the laboratory nonconforming. At the present time, all but 20 of the 100 facilities on the laboratory site are operating under waivers.

Well, you knew that when you took it over.

Dr. DRYDEN. We did.

Mr. THOMAS. You further state as follows:

These waivers make it impossible to modify any existing facilities to meet the changing program needs and thus severely restrict the potential growth of the solid propellent effort at the laboratory.

You knew that also when you took it over?

Dr. DRYDEN. We did and we knew also that the Army planned this facility.

Mr. THOMAS. You further state as follows:

The recently acquired 60-acre site has now permitted the relocation of several solid propellent facilities and associated equipment to a location where required safety code standards can be met. This project provides further relocation of additional solid propellent facilities.

Dr. DRYDEN. May I remark, Mr. Chairman, that this laboratory was responsible for the development of the first JATO assist takeoff rockets for airplanes, supported at that time by General Arnold, and they are one of the small groups doing research in solid propellants. This laboratory was built before anyone knew anything about solid propellent rockets and there were few safety provisions provided.

At the time we took this over the Army had this modernization plan underway. If you will look at the drawing, which is shown there, this project involves a lot of small buildings.

Mr. THOMAS. I am not sure the Army ever won any laurels for using good judgment on most of their construction programs.

Dr. DRYDEN. I am simply saying that this situation was realized before we took it over and it was a certain situation that we could not live with as a responsible organization. You will see that these facilities are bunkers and buildings where you mix things, set apart in gullies up on the hillside with bunkers between the buildings.

Mr. THOMAS. What we are immediately concerned with are these cost items which involves buildings, buildings, buildings.

Dr. DRYDEN. There is $1,954,000 involved in this program.

Mr. THOMAS. Here are about six buildings. How firm are these cost figures and who made them?

Dr. DRYDEN. These are made by the groups at the laboratory. I do not know the exact basis.

Mr. THOMAS. I do not have the total figure here for all of your construction at the laboratory this year. What is it? Is it $9.5 million?

Mr. ULMER. We have $5 million in this estimate and we are proceeding with construction totaling a little over $7 million that you gave us in 1960. If you could turn for a moment to the chart on page——

Mr. THOMAS. What is the total in the budget this year?

Mr. ULMER. About $5 million.

Mr. THOMAS. And, you are now in the process of either obligating or spending on construction the $7 million for last year?

Mr. ULMER. Yes, sir; that is right.

Mr. THOMAS. So, for construction you have $12 million in the laboratory since you have been there?

Mr. ULMER. Yes, sir.

Mr. THOMAS. Is that the end of it—of the construction program?

Dr. DRYDEN. I would expect at any of our laboratories there will be a continuing need for modernization and improvement in order to keep up with this art, at some level based on a percentage of gross plant value. Many numbers have been quoted, but the general order of magnitude that we have been carrying for a number of years is probably what it will be. This program does not stop. You do not stand still. This is true in any industrial plant as well as in a Government plant in a highly technological field. So, I would be wrong if I said that expenditures for building—capital expenditures—stop. I could not tell you what the items would be even next year. I do not know at this time.

LIQUID PROPELLENT TEST CELL

Mr. THOMAS. Next is your "Liquid propellent test cell."

At this point in the record we shall insert pages 373 and 375 of the justifications.

(The pages referred to follow:)

LIQUID PROPELLENT TEST CELL

1. Description

Liquid propellent test cells.—This facility consists of three liquid propellent engine test cells, each capable of accommodating two motor mounts for research investigations of combustion, heat transfer, and engine systems. Buildings will be constructed of reinforced concrete with 800 square feet of area in each building. A sketch of a typical cell is shown on the following page.

Control building.—The control building will be used for remote operation and control of the test cells, and will require air conditioning. In addition, the building will be used for rocket-engine assembly and repair. It will be of frame stucco construction providing about 1,050 square feet of area.

Ready storage.—Three separate propellent ready-storage docks will be provided.

Equipmnt.—Instrumentation, engine controls, propellent tanks and transfer system, sound suppression equipment, a supersonic diffuser for engine testing, and a nitrogen system will be provided.

2. Justification

The jet propulsion was established before safety codes dealing with liquid propellent rockets were available. Subsequent safety code standards have made most of the liquid propellent rockets test facilities at the laboratory nonconforming. At the present time, all but 20 of the 100 facilities on the laboratory site are operating under waivers. These waivers make it impossible to modify any existing facilities to meet the changing program needs and thus severely restrict the potential growth of the liquid propellent effort at the laboratory. A part of the liquid propellent facilities of the laboratory are being moved into a newly acquired 60-acre site on which safety standards can be met. This project will complete the move of the liquid propellent facilities and thereby eliminate the waivers of the ordnance safety manual under which the liquid propellent section is now operating.

3. Cost estimate

Buildings	$190,000
3 test cells at $43,000	129,000
1 control room	21,000
3 docks	15,000
Utilities	25,000
Equipment	172,000
Valves, piping, tanks for 4 test cells	70,000
Machine tools	10,000
Nitrogen cascade	12,000
Sound suppressors	80,000
Instrumentation	138,000
Central recording system between instrumentation building, test cells, and control building	124,000
Instruments	14,000
Total estimated cost	500,000

4. Construction schedule

Total estimated completion time, 10 months.

Mr. THOMAS. This involves a total cost of $500,000 with a lead-time of 10 months.

You have listed here a building in the amount of $190,000.

Your justifications state as follows:

This facility consists of three liquid propellant engine test cells, each capable of accommodating two motor mounts for research investigations of combustion, heat transfer, and engine systems. Buildings will be constructed of reinforced concrete with 800 square feet of area in each building.

How many buildings are there? Is that No. 3?

Dr. DRYDEN. I would not call this a building myself. If you will look at the diagram, you will see that it is a large amount of reinforced concrete to isolate propellent tanks from test cells.

Mr. THOMAS. How many square feet are in it? I believe it is 800 square feet at a cost of $190,000.

How much is that a square foot?

Dr. DRYDEN. There are three test cells at $43,000, a control room at $21,000, three docks at $15,000 and utilities at $25,000. The whole installation totals $190,000. The square footage of a structure like that does not have very much significance.

Mr. THOMAS. That is the smallest part of it.

Dr. DRYDEN. What you are doing is protecting against explosion hazards by having enough concrete between the rocket you are testing and the people in order to protect them.

Mr. THOMAS. What we were talking about is the cost per square foot of your concrete structure.

If I were working with those explosives, I would want it pretty thick myself.

I am just trying to find out what the cost is.

Mr. ULMER. The square-foot cost comes to a little over $50.

Mr. THOMAS. $50 a square foot?

Mr. ULMER. Yes, sir.

Mr. THOMAS. Its walls must be thicker than those that you have at the Atomic Energy Laboratory. Some of those are 2½ or 3 feet thick.

Dr. DRYDEN. They are approximately 3 feet thick.

Mr. ULMER. Plus the fact that the ceiling is concrete.

Dr. DRYDEN. The ceiling looks like about 2 feet thick.

Mr. THOMAS. At $50 a square foot that is expensive concrete pouring.

Dr. DRYDEN. It is reinforced concrete. It is heavily reinforced.

Mr. THOMAS. You could have a lot of steel in there for $50 a square foot.

Dr. DRYDEN. There is one small item in JPL, Mr. Chairman, of $150,000 in addition to this.

Mr. JONAS. Is that the antenna range?

Dr. DRYDEN. Yes, sir.

HUNTSVILLE FACILITY

Mr. THOMAS. Let us take a look at your Huntsville operations.

General OSTRANDER. Mr. Chairman, if I may, I would like to make sort of a general statement here on both the Huntsville facility and the Army facility.

Mr. THOMAS. We will be delighted to hear you, and in your statement—I have written down here "Why all this construction when the Army is out of the space business?"—tell us why the Army cannot vacate this facility and turn it over to you instead of your going in there and duplicating facility after facility.

Have you been to the Bureau of the Budget and asked them to work out this?

Dr. DRYDEN. Yes, sir.

Mr. THOMAS. We have an idea it might be well to go back and consult them again.

You are spending here $26,750,000 and it looks like to me that at least one-third or one-half of this could be cut down. If the Army were in the space business, that would be one thing, but they are out of the space business.

Dr. DRYDEN. The greater part of this is for facilities in connection with our SATURN program.

This whole transfer plan was reviewed by the Bureau of the Budget as well as by the various levels on the Department of Defense.

I think, perhaps, what you are referring to——

Mr. THOMAS. With all the installations which the Army has scattered all over the country, why can they not vacate this facility? If they were in the space business it would be something else, but they are out of the space business.

Dr. DRYDEN. There are two Army buildings which are not connected directly with space activities. One in the administration building.

Mr. THOMAS. Do you have to build a new administration building?

Dr. DRYDEN. This I want to discuss with you. As I say, there are two buildings not connected with space—an administration building and a computer building.

The Army has had in its construction program for some time a need for additional administrative space. I do not know where it stands in their program.

They also have a continuing requirement for a computer facility for some of their inventory control throughout the country.

The agreement that was reached was that we would continue to occupy space in the ABMA administration building until some other solution could be worked out, and that we would take up with the Bureau of the Budget the construction of our own central laboratory and office building in the NASA budget.

The Army agreed that they would take up in their budget the construction of the computer building. These are the only two buildings for which it was impossible to make a clean division between the Army functions and those being transferred to NASA. Since these two buildings are not specifically for space work the Army felt that they could not surrender the title. They will surrender the title to the computer building but retain the title to the administration building.

That is a simple statement of the situation.

Mr. THOMAS. If they can't surrender the title, what difference does it make where the title is? It is a question of occupancy and use.

Dr. DRYDEN. They said they could not surrender the use of this building and that they would have to provide space to carry on their continuing activities and continuing responsibilities in the missile field.

I, myself, was not directly involved in these negotiations.

I do not know whether Mr. Siepert wishes to say something more about this.

Mr. THOMAS. It looks like to me that the taxpayers could well afford to ask you people to go back to the Bureau of the Budget and let the Bureau of the Budget take another look at this thing.

We do not expect the Army to give up anything. That is not their policy.

Dr. DRYDEN. I think the Government will build two more buildings eventually whether they are in the military budget or in our budget, and it depends on the result of how things come out here.

Mr. RHODES. What facilities does the Army need at Huntsville?

Dr. DRYDEN. Well, if you will look at the plot plan, they are giving up all the buildings of the Development Operations Division—the laboratories that were occupied by the scientists and the facilities that are being used in the construction of SATURN as well as the test stands.

They have retained all of the buildings occupied by their rocket branch in the missile business, and they have the Redstone Arsenal facilities. There are 20,000-and-some-odd people at the Redstone Arsenal, and we took only 5,500 of them. So, there are 17,000 Army people left at the Redstone Arsenal.

Their responsibilities have to do with the shorter range missiles and the rocket weaponry of the Army. The headquarters of their ABMA missile center is located there under General Barclay. General Barclay and his staff are in this administration building. Dr. von Braun shares some space in the building.

We have an agreement that will continue until there is a solution to this building question of whether or not the Army builds a building or NASA builds a building.

Mr. THOMAS. Why do you have to have a computer separate from the Army? Why can you not use the same computer?

Dr. DRYDEN. They have a demand for almost full-time use in controlling their military weapons inventory. It is not the same type of use as ours at all. They must have under Army control a means of handling inventories of their missile stocks throughout the arsenals. This is the headquarters, as I understand it, for that inventory control.

Our use of the computers, as stated the other day, is in connection with the design of vehicles, for the computation of orbits and requirements for launching. Computation facilities for this sort of work must be under NASA control. For example, any of these launchings toward the moon have to be figured out for the day and year that the flight is going to be made. You cannot compute it once and for all.

Mr. THOMAS. Is this the only computer you will have in your shop?

Dr. DRYDEN. Not at all. This is the one connected with the vehicle design and trajectory. This one happens to be the biggest installation. At Goddard is one which will come fairly close to it in size but designed for reduction of the large amount of data obtained from the tracking and telemetry network.

Mr. THOMAS. Every installation has its own computer?

Mr. HORNER. Computers are very much like slide rules. Every engineer has a slide rule and every major installation doing scientific work has to have a computer facility of some kind, or it is just a waste of time.

Mr. RHODES. The only trouble is that computers cost more than slide rules.

Mr. HORNER. They do, sir.

Mr. RHODES. I would be glad to buy every engineer a slide rule if if we could avoid this cost.

Dr. DRYDEN. A trajectory computation which would take a group of people a year to do in the old days can be ground out now in about 5 minutes. This is the difference.

Mr. HORNER. I think the important thing to recognize at Huntsville is that the assimilation of that group into the space business has resulted in a net increase of work at Huntsville. It is going to require more people and more facilities than the work which is being carried out by these people at the rate of $70 million this current fiscal year. The proposal that we have in this budget request is for $230 million level of effort there, a growth of three times the level of effort in the SATURN development.

General OSTRANDER. All of these facilities, both at Huntsville and at the Atlantic Missile Range, with the exception of the one that Dr. Dryden mentioned, are a direct outgrowth of the proposed expediting of the SATURN program which is contained in the President's request to Congress for the additional $113 million.

The Army had already budgeted, or had proposed to budget, some $13 million of these facilities, based upon the previous SATURN schedule.

In the new schedule what we are doing is speeding this up by approximately 1 year. This means that we can get to a firing rate—construction and firing rate—of the booster of some six per year in 1964 and 1965 rather than in 1966.

Dr. von Braun is actually building these first-stage boosters that I mentioned yesterday in his facilities at Huntsville. He also has to static test them there and he also has to fire them at the Atlantic Missile Range.

This is purely a question of physical space and test and launching facilities as a result of this increased schedule.

Mr. THOMAS. We are talking about your construction.

You have as well as I remember almost 200 buildings out there—150 or 200—on that tremendous complex.

The Army is out of the space business. This comes easy and it goes easy. Of course, the Army is not going to give up anything. That is traditional with them.

Why go and spend all of this $26,750,000 for new construction when it looks like to me that some arrangement could be made through the Bureau of the Budget. The Bureau of the Budget is going to have to lay down the policy here.

At least half of this $26,750,000 for construction could be saved.

We shall insert into the record at this point the table with reference to the Huntsville projects.

(The table referred to follows:)

NASA Huntsville facility (Huntsville, Ala.)	$26, 750, 000
SATURN static test facility	10, 800, 000
Central laboratory and office facility	4, 400, 000
Dynamic test facility	600, 000
Pressure test cell	650, 000
Extension to assembly building	2, 500, 000
Addition to engineering building	1, 137, 000
Completion of guidance and control building	1, 948, 000
Addition to fabrication laboratory	215, 000
Addition to checkout building	4, 500, 000

Dr. DRYDEN. What you have said has no application whatever to SATURN static test facilities or to the dynamic test facilities.

The additions to several of the other buildings are simply to provide the space to accelerate the work on SATURN.

Mr. THOMAS. But you took over a good many buildings down there for maintenance which they do not need and certainly some of them could be used for this purpose.

Dr. DRYDEN. Not at all; not a single one.

General OSTRANDER. It is a matter of sheer size. Take for example, this complex of buildings which includes the assembly building, the fabrication laboratory, the checkout building, and so forth. We have to build and assemble these SATURN vehicles which are some 21 feet in diameter and which go out to 200 feet long when assembled.

There are other buildings on the installation but they simply are not large enough physically to accommodate the physical construction and assembly of these vehicles.

Mr. SIEPERT. I might say this: The facilities that Dr. von Braun has been using for his technical operations, each and every one of these have been turned over to NASA. The Army has not held any of these. The thing we find, however, is that these facilities were those which the Army created for Dr. von Braun in order for him to build

specifically the REDSTONE, the JUPITER, and the PERSHING missile systems. These are midgets compared to the SATURN booster program.

With respect to the Army's continuing use of those buildings, that is, those buildings which they did not give us, there is literally only one and that calls for joint interim occupancy of the Central ABMA Headquarters.

CENTRAL LABORATORY AND OFFICE FACILITY

Mr. THOMAS. Let us start out with this new Headquarters Building of 205,000 square feet. What is that going to cost?

Dr. DRYDEN. $4,400,000.

Mr. THOMAS. Your justification states that the facility will house a cafeteria, a library, a small auditorium, a conference room, and equipment rooms for specialized computing equipment.

What is the cost of this building?

General OSTRANDER. This is the building that Dr. Dryden was talking about which would make provision for Dr. von Braun's immediate headquarters staff and three of his laboratories which are currently housed in the headquarters of the Army Ballistic Missile Agency.

Mr. THOMAS. Is this the figure you use of $4,400,000?

Dr. DRYDEN. That is the total cost, yes, sir.

Mr. SIEPERT. This is $17 a foot for the construction of the building.

Mr. THOMAS. You have a nice, big building there now at your headquarters, do you not?

Dr. DRYDEN. But, the Army says it will continue to need that.

Mr. SIEPERT. The Army will be continuing to have responsibility, and I believe their figures are for between $1.5 and $2 billion worth of development and procurement business in the missile field, all based on ABMA, and they will recreate the Ballistic Missile Agency in a way to take over responsibility for nonspace missiles.

Mr. THOMAS. Well, we can all agree that they are out of the space business, are they not?

Dr. DRYDEN. They are.

Mr. THOMAS. The large part of their activity in the past has been in that field.

Dr. DRYDEN. The activities of 5,500, roughly, out of the 20,000 people. About one-fourth of the people at Huntsville were in space and PERSHING and JUPITER missiles.

Mr. THOMAS. But, they have been completed, have they not?

Dr. DRYDEN. The JUPITER is completed but the PERSHING is a very active project still.

Mr. THOMAS. That is a tactical weapon, is it not?

Dr. DRYDEN. Yes, sir.

STATIC TEST FACILITY

Mr. JONAS. What are you going to do? The thing that worries me about this construction program is this: Your first item is in the amount of $10 million with reference to the SATURN static test facility.

What are you going to do in the interim during these 30 months in which that is being constructed?

Dr. DRYDEN. The first static test facility is coming into use; our request is for the second one. The situation now is that if there is an accident, then we are delayed for a very long time. We are accepting some risks because this second stand will not be finished by the time we start our first static test on the other stand, but we are at least trying to get this leadtime so that an accident of one stand does not hold up the project for a year.

General OSTRANDER. In addition to that, Mr. Jonas, we will physically need it simply from the rate of construction and test of these first-stage boosters. In other words, we go to a rate of beyond that which one test stand will handle.

Dr. DRYDEN. In the later years as the program moves forward, we will need the two stands for the number of vehicles that are in the program, but the reason for starting it as quickly as we can is to get some protection against a delay of a year caused by an accident on one test stand.

Mr. JONAS. Why would it take 2½ years to build?

Dr. DRYDEN. I wish we had some pictures of men in it. This stand is 183 feet to the lower part of the upper platform. The missile itself, as has been mentioned, is 21 feet in diameter.

Mr. HORNER. The first stage of the missile is 80 feet.

SPEEDUP OF SATURN PROGRAM

Mr. RHODES. Dr. Dryden, who made the decision to speed up this SATURN program?

Dr. DRYDEN. This was made by the President himself.

Mr. RHODES. Was it made before the transfer of the Huntsville facility or after?

Dr. DRYDEN. It was after.

Mr. RHODES. Now, we have been talking for the last several days about the difference between a crash program and a rush program.

Dr. DRYDEN. Yes, sir.

Mr. RHODES. Would you say we are now entering into a crash program as far as the SATURN is concerned?

Dr. DRYDEN. No; it is a rush program.

Mr. RHODES. It is a rush program?

Dr. DRYDEN. Yes, sir. Before this it had been going along at a rate fixed by the number of dollars you had to spend for it.

Mr. THOMAS. This is a spare.

General OSTRANDER. If we go at the rate we propose, we will actually need it and will be using both test stands full-time at the time we get to a six-a-year rate.

Mr. THOMAS. I will read your own language:

> Of perhaps even greater importance are operational advantages mentioned, it is the backup given the present stand in the case of an accident.

Mr. ULMER. It serves both purposes.

Mr. HORNER. Mr. Thomas, there is one thing that perhaps should be said about this and that is that the Army had, of course, prepared tentative plans for an expedited SATURN program before the Huntsville facility was turned over to NASA, one plan of which corresponded with the accelerated program which was later approved by the President. The Army had to carry out that construction program to accommodate this increased rate of SATURN and General

Barclay testified before the Legislative Committee with regard to this plan. This plan went through the same items that we have here, item by item, with only minor differences, with the exception of the central laboratory building.

Mr. THOMAS. I have looked over this and it looks like to me that if there is any justifiable item in your program, this static test facility is it.

Then, we have your office building and your extensions here which look like to me certainly could be avoided.

Mr. HORNER. The point I was trying to make, Mr. Thomas, was that all these extensions, with the exception of the central laboratory building, was included in the Army program, and some of the extensions were larger than these. Therefore, the total amount of the proposed Army construction program——

Mr. THOMAS. Well, of course, the Army was competing with the Air Force, the Navy and everyone else, but that is about over with.

Dr. DRYDEN. There is no competition on SATURN. I do not believe there was any conflict in program with SATURN.

Mr. THOMAS. That is right. That is why I said, while they are completely out of the space business——

Dr. DRYDEN. I think you ought to ask Dr. von Braun some of these questions, Mr. Chairman.

Mr. RHODES. Does the fact that this program is speeded up and that you will have an operational missile a year ahead of time, cause the total cost of the project to increase or not? Are you actually going to spend more money per missile by speeding up, or would it be about the same?

Dr. DRYDEN. It is about the same.

It will actually be reduced somewhat.

Dr. von Braun says it will be reduced somewhat, but I cross my fingers on that one.

Mr. RHODES. That is the reason I asked the question.

General OSTRANDER. Well, I simply wanted to make the point that Dr. Dryden did, that all these facilities are directly tied, with the exception of this one, to this increase in this schedule—of speeding it up by 1 year. It is purely a matter of sufficient space and sufficient facilities in order to reach the rate of production, checkout and launch that we have to do in order to meet this increased schedule.

In connection with your question on the provision of additional buildings by the Army—in general, in the case of most of these things, while they have small buildings on the Huntsville reservation down there, they simply are not large enough and not suited for actual fabrication or checkout of these boosters. You just cannot get them in there.

Mr. THOMAS. I walked through some pretty large buildings.

Dr. DRYDEN. There is one shop that does make the SATURN. You probably saw it under assembly.

Mr. THOMAS. Well, it looks like to me that here is a program, without slowing down your efforts, that could be cut at least 50 or 60 percent.

As far as the big office building is concerned I do not think that is needed.

Your big pilot plant here when it gives you some standby facilities certainly, perhaps, that may be advisable. That is your big $10.8

million item. All of this other construction looks like to me could be eliminated and not slow down your program one iota.

Dr. DRYDEN. Mr. Chairman, I am sorry to disagree with you. What you saw at Huntsville will build about two SATURNS. It will take care of about a rate of two SATURNS.

Mr. THOMAS. Of course, you are not going to build the SATURN there. You are going to build that at the farthest corner of the United States and transport it back to you over land.

Dr. DRYDEN. The first stage will be built there and it will be taken to Florida by barge down the Tennessee River and through the Gulf of Mexico.

Mr. THOMAS. I am talking about your future program—your prototype.

Mr. HORNER. No, sir. The facilities are being set up there for the construction of the operational first-stage SATURN at Huntsville continuously. That is what these facilities are for.

Mr. THOMAS. You do mean to say the entire unit is going to be fabricated there?

Mr. HORNER. The first stage.

Dr. DRYDEN. The first stage of the entire unit. This has been done by Dr. von Braun in the past.

General OSTRANDER. At some stage out in the future—well in the future—this may be given completely to a contractor, and if we did that we would need practically the same order of facilities as a contractor plant as we need here.

Mr. JONAS. You say that sometime during the program you may find it advisable to let out the first stage on a contract. If you do so, will it not then be necessary to duplicate these facilities, if they are constructed?

General OSTRANDER. Well down in the program, it is conceivable that one of three possible approaches would be taken: either give it completely to a contractor or have the contractor actually assemble them. Much of the first stage is actually fabricated by a contractor and assembled here now. We could possibly turn over some of these facilities that we are talking about to a contractor to test and check it out.

Mr. JONAS. You mean that has not been determined firmly?

Mr. HORNER. The facility we are talking about here supports the fabrication and assembly of SATURN vehicles at the rate of six per year. If at some point in the space program it is decided that we need more than six per year of the SATURN vehicle, then we will have to provide additional facilities someplace and they probably would not be at this particular facility complex.

Mr. JONAS. You mean that in the middle of the program you might decide to contract it out?

Mr. HORNER. No, sir; not in the development program nor in any program at a production rate of less than six per year.

Mr. THOMAS. Of course, when they get it developed, then they will turn it over to industry like they do everything else.

Mr. HORNER. That is not the intent.

Dr. DRYDEN. The numbers are so small that this does not look like the sensible thing to do at the moment.

Mr. THOMAS. You plan to build six a year for several years, do you not?

Dr. DRYDEN. Yes, sir; but that is a pretty small production rate.

Mr. THOMAS. What would a completed unit cost at your present estimates if you included your research and development? What would your first unit cost be, and what would be the cost of your third, fourth, and fifth units?

Dr. DRYDEN. I did not quite understand whether you wanted to include the research and development costs, but our present program calls for a total, through the 10th first stage—and the upper stages that go with those—of between $800 and $900 million, approximately $850 million.

Mr. THOMAS. That includes your research and development cost?

Dr. DRYDEN. That includes the development cost; yes, sir.

Mr. THOMAS. When you get that successfully behind you, what will be your unit production cost?

Mr. HORNER. We have various estimates as to the cost of the total vehicle or the total useful vehicles of three stages which is a particular version called the C–1 version of $20 million. These are estimates of 4 to 5 years hence. So they have that degree of reliability.

Mr. THOMAS. You will have a cost of $20 million as against $850 million in your research and development cost of your first engine?

Dr. DRYDEN. The first 10.

Mr. THOMAS. $850 million for your first 10?

General OSTRANDER. Yes, sir; that is right, plus research and development and plus launch.

Mr. HORNER. The $850 million is a round number. I think it has been accurately stated at $886 million.

Mr. THOMAS. Certainly, your research and development cost on your No. 1 will be a whole lot more than on your 10th one, and certainly after you build 2 or 3 that cost ought to come down, should it not?

Dr. DRYDEN. That is right.

Mr. HORNER. That is certainly true on the first stage. The first three vehicles will not have the upper stage on them.

Mr. RHODES. Where are you developing the upper stage?

Mr. HORNER. The top stage of the first version is being developed at Convair and the middle stage is presently in the process of source selection. We have asked for proposals and we have received them from industry and we are currently evaluating them.

Mr. RHODES. What type of fuel does the middle stage use?

General OSTRANDER. Hydrogen-oxygen.

Mr. THOMAS. Is not the best guess that when your first one is completed—you first, second, and third stage—and you have it operational, that from then on out you will turn the whole thing over—first, second, and third stages, which is a completed unit—to some manufacturing firm?

General OSTRANDER. I would be very doubtful about that. We will have had the experience and facilities at Huntsville at that time and those people will not be skilled in doing any other vehicle. It is almost certainly true that they will be continued in the process of fabrication and assembly of the first stage.

Mr. THOMAS. It will be a fabrication process and you certainly have no monopoly on any stage of it. You are only going to develop the first stage and industry will develop the second and third stages?

Dr. DRYDEN. That is right.

Mr. THOMAS. If they develop those stages, after you do the research and development of stage No. 1, why cannot they do all three stages?

Mr. HORNER. They would require these kind of facilities we are talking about, Mr. Thomas, which is probably the best reason.

Mr. RHODES. Where will you assemble the missile?

Mr. HORNER. The first three missiles will be assembled at Huntsville.

Mr. RHODES. All three stages?

Mr. HORNER. Yes, sir. Later, when we have full assurance that the three stages are well matched and the electronic supports are matched and the whole circuits are matched, it is our plan that the assembly will be made at the launching site at Cape Canaveral.

Mr. THOMAS. But, my guess is you will turn over that facility to an industrial firm and they will carry on with your own facilities and it will not be necessary to build any additional ones.

The pressure is on all throughout this Government to get the Government out of business and this will be one of the first steps that will be pounced upon right here.

STATIC TEST FACILITY

At this point in the record we shall insert pages 380, 384, and 385 of the justifications.

(The pages referred to follow:)

SATURN STATIC TEST FACILITY

1. Description

The construction and instrumentation of a tower is required to permit the captive testing of space vehicles in the general class of the first stage of the SATURN vehicle. The project includes all site improvements, utilities, support buildings, and equipment required to make the project fully usable, except for equipment that must be tailormade to suit individual vehicles. The tower itself will consist of a heavy-steel structure capable of carrying all vertical loads, both static and dynamic; and a light structure which will take horizontal loads from engine gimballing or from winds, which will support service and work platforms, and which will also carry a gantry crane with its system of tracks. Leading from the tower will be a shallow, concrete-lined trench which will drain the deflector cooling water to a holding pond, which, in turn, will discharge into the Huntsville Spring Creek. Immediately adjacent to the tower will be a two-story concrete building for terminating instrumentation and control cables and for housing special power generators and power switch panels. A cable tunnel will lead from the termination building to a new instrumentation and control blockhouse, which will also be connected to the existing blockhouse and instrumentation system through a bank of conduits. In the new blockhouse will be all control equipment, and consoles needed for the proposed tower and half the recorders needed for testing the SATURN first stage at the new tower with the remainder of the recording being down in the existing blockhouse. Space will be available to add additional instrumentation in the future.

Site work in the project will consist of access roads and railroads: general grading, hardstands, and area drainage; utilities including powerlines, potable water mains, sanitary sewer lines, and septic tanks; and a high-pressure industrial water system. A reservoir and pumps for supplying deflector cooling and firefighting water will be provided. Supporting facilities will include a small maintenance-shop building; fuel and liquid oxygen storage tanks and piping systems; and high-pressure nitrogen and air storage bottles and piping networks.

2. Justification

This facility will be used to perform captive testing of the complete first stages of the SATURN space vehicle. Such testing is required—

(*a*) To prove design concepts.

(*b*) To establish engine operational limitations.

(*c*) To determine the effects on engine operation and efficiency of a single-engine malfunction.

(*d*) To establish statistical data on reliability.

(*e*) To provide a final operational check on flight vehicles.

An existing static test tower does not have the capability of handling an accelerated flight program while at the same time conducting an extensive research and development program. The construction of a second stand will remove this conflict. Of perhaps greater importance than the operational advantages mentioned is the backup given the present stand in the case of a catastrophe. The additional stand will allow the SATURN program to proceed even if an explosion seriously damages the existing stand.

3. Cost estimate

Tower	$1,900,000
Deflector trench and pond	260,000
Site work	170,000
Fuel storage and handling	170,000
LOX storage and handling	450,000
High-pressure gas system	330,000
Position support building	60,000
Industrial water system	370,000
Outside utilities	130,000
Instrumentation and control equipment	4,510,000
Gantry crane	440,000
Blockhouse	730,000
Design and engineering services	1,280,000
Total estimated cost	10,800,000

4. Construction schedule

Total estimated completion time, 30 months.

Mr. THOMAS. This deals with your static test facility in the amount of $10.8 million.

The justifications break down your cost estimates which is a total of $10.8 million and which requires 30 months of construction. These estimates are made up of a tower in the amount of $1.9 million, the deflector trench and pond in the amount of $260,000—you can build a whote lot of pond for $260,000.

Then you have site work in the amount of $170,000; fuel storage and handling in the amount of $170,000; LOX storage and handling in the amount of $450,000; high-pressure gas system in the amount of $330,000; position support building in the amount of $60,000; industrial water system in the amount of $370,000; outside utilities in the amount of $130,000; instrumentation and control equipment in the amount of $4,510,000 and your gantry crane in the amount of $440,000. Then you have your blockhouse in the amount of $730,000 and your design and engineering services in the amount of $1,280,000.

You can build a lot of blockhouse for $730,000.

How firm are these estimates and who made them?

General OSTRANDER. They were made by Huntsville and I think they are fairly firm because they have had about 10 years of experience

in building this type of facility, including one similar to this, although on a smaller scale.

Dr. DRYDEN. One has been built by the Corps of Engineers and these costs are based on their experience.

Mr. THOMAS. These figures were not submitted by the Corps of Engineers; were they?

Mr. HORNER. These are based upon the Corps of Engineers costs.

Mr. THOMAS. Who is going to do this construction work and how will it be handled?

General OSTRANDER. This will be largely handled through the Corps of Engineers and it will be done on competitive bids with industry.

Mr. THOMAS. Why in this instance are you using the Corps of Engineers? Is that based upon the same reason as that at JPL, because it is a military installation?

General OSTRANDER. The Corps of Engineers has developed quite a good deal of competence in constructing these static test and launch test stands over a period of years and we want to take advantage of their competence.

CENTRAL LABORATORY AND OFFICE FACILITY

Mr. THOMAS. At this point in the record we shall insert pages 386 and 388 of the justifications into the record.

(The pages referred to follow:)

CENTRAL LABORATORY AND OFFICE FACILITY

1. Description

This project provides for the construction of a combined laboratory and office building to house personnel of the aeroballistics and research projects laboratories plus staff personnel of the NASA Huntsville facility. The proposed multistory building will provide a gross area of 205,000 square feet and a net area of approximately 144,000 square feet. In addition to the laboratory and office areas, the facility will house a cafeteria, library, small auditorium, conference rooms, equipment rooms for specialized computing equipment, and heating and air-conditioning equipment. Drawings of the proposed construction are shown on the following page.

2. Justification

The proposed transfer of the ABMA development operations division to NASA and the resultant agreements necessary to provide an equitable share of buildings to both the Army and the NASA, will result in extreme congestion in many areas of operation in the development operations division. The greatest shortage of space will occur as a result of the agreement to retain buildings 4488 and 4484 for Army use. These buildings now house the aeroballistics laboratory, the research projects laboratory, and staff offices of the missile firing laboratory and the development operations division. In addition, space must be provided for supporting personnel who will be transferred to NASA.

The aeroballistics laboratory performs research and development in the fields of theoretical aerodynamics, flight mechanics and vibration, flutter, and guidance theory to provide a basis for the optimum design of space vehicles and the optimization of trajectory and orbit calculations. In addition, the laboratory conducts analytical investing action of test flights, compiles and analizes meteorological data for applications to vehicle design, and carries on applied supporting research in the fields of aeroballistics and related sciences.

The research projects laboratory coordinates and supervises supporting research programs, provides scientific coordination for various special research projects, and conducts independent research in thermal design, nuclear power problems, and space physics. The missile firing laboratory has the responsibility for all NASA Huntsville facility firings at Cape Canaveral. The office of the director of the missile firing laboratory and his staff are located at Huntsville. The office of the director of the NASA Huntsville facility and supporting personnel provide supervision, and technical and administrative sup-

port to the 10 laboratories of ABMA development operations division which will compromise the NASA Huntsville facility. A total of 1,045 personnel will be housed in the building proposed for construction under this project.

3. Cost estimate

Site preparation	$20,000
Roadways and parking areas	110,000
Building (including heating and air conditioning)	3,485,000
Utilities	100,000
Communications	200,000
Collateral equipment	100,000
Design and engineering services	385,000
Total estimated cost	4,400,000

4. Construction schedule

Total estimated completion time, 20 months.

Mr. THOMAS. This item involves a total project cost of $4.4 million. Your justifications state as follows:

This project provides for the construction of a combined laboratory and office building to house personnel of the aerial ballistics and research projects laboratories plus staff personnel of the NASA Huntsville facility. The proposed multistory building will provide a gross area of 205,000 square feet and a net area of approximately 144,000 square feet.

We have a lot of hallways in there.

Your justifications further state:

In addition to the laboratory and office areas, the facility will house a cafeteria, library, small auditorium, conference rooms, equipment rooms for specialized computing equipment, and heating and air-conditioning equipment.

You do not have any more people on the compounds now than you had last year, do you, and the people got along very satisfactorily, did they not?

You are increasing your staff less than 500.

Dr. DRYDEN. I cannot answer authoritatively as to how many people the Army will have in connection with the work on their missiles and other activities at Huntsville.

Mr. THOMAS. This looks to me as though it is one item which could be deferred.

Mr. SIEPERT. The Army, Mr. Chairman, in the negotiations told us that the continuation of their missile program gave them a manpower requirement of 1,500 people more than were in the total REDSTONE Arsenal setup. I do not know the extent to which this manpower has been approved.

In addition to the 1,500 more—that is their deficit—it will be necessary for us to replace 400 people on our side of the organization which they say they cannot give us because they are needed in the Army organization.

This, then, represents a substantial increase in the total numbers of people that are needed to be housed in office space on the REDSTONE Arsenal. For this reason, the Army from the very beginning of the negotiations said they could not give us the ABMA headquarters building.

Mr. THOMAS. I do not believe the Military Construction Subcommittee has passed upon the Army's industrial program for 1961 as yet. Until that becomes clear, it might be well to hold this in abeyance.

General OSTRANDER. We, incidentally, Mr. Chairman, have made a physical survey of all the other buildings and there is no additional space which we could use.

Mr. THOMAS. General, please say that out loud so we can understand you.

General OSTRANDER. I say we made a physical survey of the other buildings in the complex which is being transferred from the Army to NASA, and there is no additional space in which these people can be placed.

Mr. THOMAS. It is my understanding that the Army was transferring to NASA a good many buildings which the Army could not use and which NASA could not use either but NASA has the responsibility of maintenance.

Dr. DRYDEN. No, sir; there are no buildings transferred that are not used.

Mr. THOMAS. How many buildings were transferred to you? You set that number out in your justifications. I believe it was 81.

Dr. DRYDEN. It was a very large number.

Mr. SIEPERT. It was several hundred. I can supply for the record such a listing.

Mr. THOMAS. Read it into the record.

Mr. SIEPERT. There are many buildings, sir.

Mr. THOMAS. I had a figure of 81 in my own mind.

Dr. DRYDEN. They come in all sizes. There are certainly more than that.

Mr. THOMAS. Can you add them up right quick? Guess at the number and you can straighten it out later in the record. Your table shows it in the justifications as to how many there, but I do not have the figure in mind. I had a figure in mind of 81. It may be 100 off.

Mr. SIEPERT. I would say there must be close to 150 structures. The correct number of Huntsville structures of all types to be transferred for NASA use is 149.

Mr. THOMAS. And about half of them are of no use to you?

General OSTRANDER. That is not correct, sir.

Mr. THOMAS. How many?

General OSTRANDER. We have surveyed these and these buildings are all in use at the present time.

Mr. THOMAS. By whom? The Army or who?

Mr. SIEPERT. By the Development Operations Division. We only asked for buildings which were within the complex that had been assigned to Dr. von Braun for his work.

Dr. von Braun points out to me in looking at the list I have here that many of these buildings are not buildings in the sense that they are usable for personnel. These are specialized facilities such as vacuum tanks and test cells and H–202 tanks.

DYNAMIC TEST FACILITY

Mr. THOMAS. At this point in the record we shall insert pages 389, 392, and 393 of the justifications.

(The pages referred to follow:)

DYNAMIC TEST FACILITY

1. Description

This project provides for the construction of a facility at which the large, multistage SATURN vehicles may be assembled and subjected to various mechanical, structural, and operational tests. The facility will allow the checkout of mechanical mating features; the determination of the natural frequency of the missile, both on the launcher arms and under simulated flight conditions; the temperature effects caused by liquid oxygen or nitrogen when held for various lengths of time; and the effect of simulated flight vibrations on the various stages of the missile. There will be the capability for other tests involving wind effects, fueling techniques, ground crew training, and assembly methods sketches of the proposed facility are shown on the following two pages.

The facility will consist of two foundations capable of carrying the launcher arms and vehicle at the full flight weight. A steel superstructure will provide lateral support for the vehicle and working platforms at any point on the vehicle. The superstructure will also serve as a pedestal to support a stiff-leg derrick to be used for handling and placing the various stages. Structural members will be included to support the missile by long cables, allowing freedom in all directions, except the vertical, for vibrational studies. One of the foundations will be used for tests requiring numerous work platforms and will provide maximum support for the missile, with the other being used when minimum fixed enclosures are required. Access for personnel to upper platforms will be by stairs and an elevator.

Means will be incorporated in the project for carrying spilled propellants to remote holding ponds to minimize fire hazards. Power, water, and other utilities will be provided as needed, as well as a road, hardstands, and other site improvements. On-stand housing and conduit for instrumentation and control and for connections to the existing systems are a part of this project. Actual recording of test data will be accomplished with equipment available in an existing blockhouse.

2. Justification

The cost of large, multistage vehicles for space missions is so great that all feasible means of assuring success must be taken. In the field of preflight testing with all stages in place, and with and without full cargoes of propellants or simulated propellants on board the required testing cannot now be done anywhere in the United States due to a lack of suitable facilities. The facility proposed in this project will provide the required test capabilities. Some of the critical test areas in which this facility will be used are discussed below:

Mating and bending characteristics.—When the various stages of a vehicle are jointed together, a determination must be made as to the amount of malalinement which will occur. Any additional malalinement resulting from the additional weight of added propellants or from the intense cold of liquid oxygen being held in the missile tanks must also be measured. The structures are so complex and the degree of accuracy in measurements required are so great that any theoretical analysis must be experimentally checked. The information obtained will be used by the structural designers to check for adequate strength without excess weight and by the guidance designers to make certain that the navigational system can compensate for measured deviations from perfect alinement. The fact that the various stages will often be manufactured in different plants makes such tests mandatory.

Vibrational analysis.—The vehicles will have forces applied to them in such a way that they will vibrate at their natural frequency. This will be checked against the frequencies generated by the propulsion and guidance systems to insure that there is no chance of a destructive buildup of forces due to their being in harmony with the vehicle. Also, vibrators will be used to simulate vibrations generated by the propulsion system to insure that no part of the vehicles, particularly the guidance system, will be damaged.

Other tests.—The launcher arms and release devices will be tested by replacing the engines with hydraulic cylinders, which will lift the vehicle several inches. The test will serve the purpose of proving that all the holddowns release together. Other tests will be concerned with the effect of winds on the vehicle, the training of the launch crews, and calibration of the fuel tanks.

3. Cost estimate

Site preparation	$6,900
Foundations	23,000
Tower	221,150
Crane	120,000
Elevator	34,500
Propellent disposal system	37,500
Paving	10,400
Instrumentation conduit	5,550
Utilities	61,000
Design and engineering services	80,000
Total estimated cost	600,000

4. Construction schedule

Total estimated completion time, 10 months.

Mr. THOMAS. This project carries a leadtime of 10 months at a construction cost of $600,000.

Your justifications state as follows:

The facility proposed in this project will provide the required test capabilities. Some of the critical test areas in which this facility will be used are discussed below:

The cost of large, multistage vehicles for space missions is so great that all feasible means of assuring success must be taken. In the field of preflight testing with all stages in place, and with and without full cargoes of propellants or simulated propellants on board the required testing cannot now be done anywhere in the United States due to a lack of suitable facilities.

You have here several items which make up this request and are as follows:

Site preparation, foundations, power, crane, elevator, propellent disposal system, paving, instrumentation conduit, utilities and design engineering services, for a total cost of $600,000. For your design and engineering services you are requesting $80,000 which is a little better than 12 percent of your request alone.

PRESSURE TEST CELL

Mr. THOMAS. At this point in the record we shall insert page 394 of the justifications.

(The page referred to follows:)

PRESSURE TEST CELL

1. Description

This project provides for the construction and instrumentation of mechanical test facilities that will provide the capability for pressure testing the SATURN first-stage cluster, for inspecting component parts, and for the analysis of hydraulic oil and propellant and sub-system contamination. A sketch of the proposed construction is presented on the following page.

2. Justification

There is no pressure test cell available at the NASA Huntsville facility to accommodate the test requirements for the present SATURN program. The proposed facility is necessary to provide a safe and completely blastproof area to perform mechanical, functional, and pressure testing of the SATURN booster assembly. The booster and its components will be tested in the cell for failure in strength, function, leakage, and timing. The pressure testing of the

SATURN boosters cannot be accomplished within existing facilities without endangering the building structure and its occupants.

3. Cost estimate

Building	$475,500
Utilities and paving	2,000
Heating and air conditioning	50,000
Extension of existing monorail system	3,000
Laboratory exhaust system	4,500
High-pressure, pneumatic, and hydraulic facilities	85,000
Relocation of high-pressure bottle room	10,000
Design and engineering services	20,000
Total estimated cost	650,000

4. Construction time

Total estimated completion time, 12 months.

Mr. THOMAS. This item covers your pressure test cell and is in the amount of $650,000. I note that you have a request for the construction of a building in the amount of $475,500.

What is the nature of this building and why can you not use one of the existing buildings already there?

General OSTRANDER. This has to be a specially constructed building because we are pressure testing the first stage of the SATURN in this building.

Mr. THOMAS. How many square feet are in this building and what will it cost per square foot?

General OSTRANDER. 15,000 square feet at $32 a square foot.

Mr. THOMAS. Is it to be constructed of reinforced concrete?

General OSTRANDER. It is reinforced concrete; yes, sir.

Mr. THOMAS. Is this $22 a square foot or $32 a square foot?

General OSTRANDER. I beg your pardon, sir. It is $31 a square foot. I was in error earlier.

Mr. THOMAS. What is the nature of the construction?

General OSTRANDER. It is reinforced concrete, and a part of it——

Mr. THOMAS. Is it an open warehouse type of building?

General OSTRANDER. It is an open room in which we can run these boosters up to certain pressure and test them.

Mr. THOMAS. I do not know how you are going to spend $31 a square foot.

How thick will the walls be?

General OSTRANDER. This involves not so much the building as it does many of the high-pressure devices and the instrumentation to test the equipment within the building.

Mr. THOMAS. You have hydraulic equipment in here and, I think, air conditioning, as well as exhaust systems and high-pressure pneumatic and hydraulic facilities in addition to this $475,500.

Mr. JONAS. You just make a statement that existing test cells are not suitable, but you do not give us any explanation for that.

Why are they not suitable?

General OSTRANDER. I do not believe that there is a test cell there which will accommodate the SATURN booster.

Dr. VON BRAUN. It is just too small. Our largest test cell can accommodate the JUPITER, but this has about three times the diameter of the JUPITER.

EXTENSION TO ASSEMBLY BUILDING

Mr. THOMAS. There is also an extension of your assembly building in the amount of $2.5 million.

At this point in the record we shall insert pages 398 and 396 of the justifications.

(The pages referred to follow:)

EXTENSION TO ASSEMBLY BUILDING

1. Description

It is proposed to construct and equip an addition to missile assembly buildings 4705 and 4706 to supplement existing missile assembly facilities. Space and facilities will be provided for test and quality control of subassembly and assembly work. A sketch of the proposed work is shown on the following page. The addition will provide:

(*a*) 55,000 square feet of additional space for general assembly work, including an extention of the existing bridge crane systems and the provision of necessary optical and supporting equipment.

(*b*) 6,000 square feet of additional space for pressure tests of subassembly components, including provisions for high pressure air.

(*c*) 3,500 square feet of additional area for cleaning large fuel suction lines of the SATURN first-stage booster, including required equipment for dehumdifing and dust freeing the area, water and air treatment, and general cleaning equipment.

(*d*) 12,100 square feet of additional space for production engineering, equipment, storage, and administration.

2. Justification

Existing assembly facilities were not planned or designed for the development of vehicles approximating the diameters and lengths of the SATURN and future space vehicles. Space and facilities for the development and fabrication of SATURN components is being provided by minor modifications to existing shops and by the shifting of equipment between those shops. However, the need for adequate floor space for assembly and for vehicle alinement, cannot be met without the construction of additional space. The SATURN production schedule will require space for the assembly of several first stage clustered boosters simultaneously.

In addition to providing the necessary floor space for final assembly the proposed addition will provide dust free, humidity controlled cleaning areas; quality control high pressure test facilities including required office space and facilities for other inspection work; and space for subassembly including vehicle wiring and engine buildup.

3. Cost estimate

Building	$1,700,000
Utilities and paving	50,000
Optical equipment and assembly support equipment	100,000
Cranes	150,000
Fuel suction line cleaning equipment	200,000
Pressure test equipment and instrumentation	100,000
Design and engineering services	200,000
Total estimated cost	2,500,000

4. Construction schedule

Total estimated completion time, 16 months.

Mr. THOMAS. Your justifications state as follows:

Fifty-five thousand square feet of additional space for general assembly work, including an extension of existing bridge crane systems and the provision of necessary optical and supporting equipment.

Six thousand square feet of additional space for pressure tests of subassembly components, including provisions for high-pressure air.

Three thousand five hundred square feet of additional area for cleaning large fuel suction lines of the SATURN first-stage booster, including required equip-

ment for dehumidifying and dust freeing the area, water and air treatment, and general cleaning equipment.

Twelve thousand one hundred square feet of additional space for production engineering, equipment, storage, and administration.

What is the total square footage in this building?

General OSTRANDER. 76,600 square feet.

Mr. THOMAS. What does it cost a square foot?

General OSTRANDER. $22 a square foot.

Mr. THOMAS. What will be the nature and type of the construction?

General OSTRANDER. This, I believe, is transite on steel frame.

Mr. SIEPERT. The reason that cost, Mr. Chairman, is $22 is if you look at the diagram on page 397, you will find that this building has a large amount of cubage/square footage area because it is two stories high.

Mr. THOMAS. What will be the height inside the building? Will it be 35, 40 or 50 feet?

Mr. SIEPERT. I do not know, sir.

Mr. THOMAS. You are building here a concrete, reinforced building and an open type building which should be the cheapest construction in the world, if you get a hold of a good concrete man. He will set up forms and pour it in there and do it in a whole lot less than 16 months and a whole lot less than $22 a square foot.

Dr. DRYDEN. Off the record.

(Discussion off the record.)

Mr. THOMAS. We shall now proceed to consideration of the next item.

ADDITION TO ENGINEERING BUILDING

Mr. THOMAS. This covers the addition to your engineering building and is in the amount of $1,137,000.

At this point in the record we shall insert pages 399, 403, and 404 of the justifications.

(The pages referred to follow:)

ADDITION TO ENGINEERING BUILDING

1. Description

It is proposed to construct an addition to the engineering building of the structures and mechanics laboratory. As indicated in the drawings on the following three pages, the proposed facility will include an 80- by 10-foot connection to building 4610 at the second and third floor levels and the construction of a six story 80- by 100-foot engineering buildings. The existing facility plus the addition proposed in this project will house a total of approximately 600 personnel.

2. Justification

The mission of the structures and mechanics laboratory is to conduct research and development activities in the fields of structures, mechanics, propulsion, chemistry, and materials as related to all types of space programs. Some of the key elements in the mission include:

Feasibility and design studies, and analytical investigations in the preparation of technical proposals for future spaceflight systems.

Analytical and experimental research, development, and design of structural components and complete airframes of satellites and space vehicles.

Research and development in the fields of propulsion and mechanics as related to space vehicles, including:

(*a*) Design of propulsion systems, propellant feed systems, cooling systems, mechanical assemblies, and components.

(*b*) Methods and systems for protection of the space vehicle system from aerodynamic heating.

(c) Integration of propulsion units into space vehicle systems.

Research and development activities in the field of chemistry and materials as applied to the planning, design, manufacture, storage, and operation of space vehicles.

Research and development in the layout and design integration of space vehicles, including:

(a) Development of preliminary layouts of space vehicles.

(b) Coordination of design activity and integration of design requirements of structures, aerodynamics, guidance and control, and launching and handling equipment.

(c) Analysis of weight, moment of inertia, product of intertia, center of gravity, and stability axes.

(d) Review, standardization, and approval of all drawings and specifications required for complete documentation and release of final drawing assemblies.

To accomplish this mission, the technical personnel of the laboratory must perform with the utmost efficiency. They must be adequately housed and must be closely integrated. The design and analysis personnel of the laboratory are now located in four buildings. Three of the buildings are more than ½ mile from the laboratory complex of buildings. This presents a number of problems relating to proper coordination of design effort.

The main engineering building of the laboratory now provides 32,000 usable square feet of floor space. There are 602 personnel in this building and three outlying buildings who must be brought into the laboratory complex to function efficiently. There is not adequate room in the existing building to accommodate this number of people. Based on the maximum utilization of usable floor area the total floor space required is approximately 71,000 square feet. This project will provide an additional 39,000 square feet of net usable area. Upon completion of the proposed addition, the staff of the structures and mechanics laboratory will have available an average of less than 120 square feet per person which is considered minimal for the types of personnel to be housed.

3. Cost estimate

Site work, roads, and parking areas	$70,000
Utilities and communications	59,000
Building, including heating and air conditioning	850,000
Collateral equipment	45,000
Design and engineering services	113,000
Total estimated cost	1,137,000

4. Construction schedule

Total estimated completion, 15 months.

Mr. THOMAS. What is the building itself going to cost? I notice the leadtime is 15 months.

General OSTRANDER. $850,000 is for the building and it has a gross area of 48,000 square feet at an average cost of $17.70 a square foot.

Mr. THOMAS. What is the total cost? Is that figure $1,137,000?

General OSTRANDER. Yes, sir.

Mr. THOMAS. How many square feet are in the building?

General OSTRANDER. 48,000 square feet.

Mr. THOMAS. Well, with all of these leadtimes you will be out of business before you get all of this completed, will you not?

Dr. DRYDEN. I do not think so.

Mr. THOMAS. What are you going to be doing in the meantime with reference to the equipment which you badly need?

Dr. DRYDEN. This is all time phased fairly well to meet the buildup in the number of first-stage vehicles. Right now the first vehicle is on the static test stand and the second one will be coming along shortly.

Mr. THOMAS. It looks like to me that your most important project here is going to take 37 months to complete, and if you can survive

37 months without it, it looks like to me you could go a long time without it.

Dr. DRYDEN. The date is 48 months to the 11th vehicle.

Mr. THOMAS. Here is your guidance control building. Is this under the direction of our distinguished friend, Dr. Hausern?

Dr. DRYDEN. Yes, sir.

Mr. THOMAS. He is a great man and a fine scientist as well as a fine gentleman. Please tell him hello for me, will you, Doctor?

He told us he would not swap ours for the Russians'; that ours was the best, and as far as I am concerned, I am going to believe the doctor.

Mr. JONAS. Before you leave the engineering building, I can understand why you need additional engineering capacity, but if you can go 36 months without it, I do not see why you are going to need additional buildings from then on.

General OSTRANDER. The engineering building is 15 months in the future.

Mr. ULMER. I do not understand the 36 months.

Mr. JONAS. It is 15 months? You will not occupy it for 15 months, and you are going to continue in your engineering work? If you can use existing engineering facilities in the next 15 months, how do you know that far into the future that you will need additional capacity?

General OSTRANDER. We have this group now squeezed into four different buildings, scattered about a half-mile apart, and we have about 50 square feet per person. This is timed with the SATURN program buildup which goes from one vehicle in calendar year 1961 to three in 1962 and five in 1964, and so on. At the time we reach this buildup, this building will be available.

Mr. RHODES. After you have gotten your missile perfected, is not your engineering work almost over?

General OSTRANDER. No, sir. In the first place, you have continuing work on the C–1 configuration, and you must remember we have two others called the C–2 and C–3. These are the four- and five-stage vehicles that we were talking about yesterday.

Mr. RHODES. Do you have any present plans, Dr. Dryden, for the NOVA?

Dr. DRYDEN. No, sir.

Mr. RHODES. Are we appropriating any money this year which might be used later in the NOVA program?

Dr. DRYDEN. There is no money on the NOVA vehicle at the present time. There is only the F–1 engine development which will be monitored by Dr. von Braun. I would say that the exact future of NOVA depends very much on Dr. von Braun's studies in the coming year.

Mr. OSTERTAG. You are doing the basic research?

Dr. DRYDEN. On the NOVA vehicle I think there is a little money for studies. Is that right?

General OSTRANDER. Yes, sir; some study contracts.

Dr. DRYDEN. But no hardware development contracts.

Mr. RHODES. In other words, this engineering building that we are being asked to appropriate money for is for the SATURN project alone?

Dr. DRYDEN. No, sir; anything in the vehicle line which NASA does will be under Dr. von Braun, so that he will be concerned with engi-

neering in connection with all of our launch vehicles, whatever they may be.

Mr. THOMAS. You have a half dozen buildings which you are using for engineering purposes now, have you not?

General OSTRANDER. This particular one happens to house the people who work for him. These people will be working both on SATURN and the other vehicles which he is currently charged with, and any future ones.

Mr. THOMAS. How many engineering buildings does the Army have there which they are going to use?

Mr. SIEPERT. I do not know of any others that are called an engineering building as such. Do you, Dr. von Braun?

Dr. VON BRAUN. No. It is scattered over quite a number of buildings. Some of this requirement for the engineering building actually has something to do with the divorce from the Army operation, and the Army will have to set up its own engineering in the missile area.

Mr. THOMAS. They are out of the missile business, we think, Doctor.

Dr. DRYDEN. They are out of the space business but not out of the missile business, Mr. Chairman.

Mr. THOMAS. I meant that they are out of the space business.

Dr. VON BRAUN. We are out of space but not out of missiles.

Mr. THOMAS. Well, perhaps, it will not be long until you will have a centralized agency on most of your tactical weapons as well as some of your other weapons.

Dr. VON BRAUN. After the separation, there will be more total engineering costs than there are now, and I think this is a point: The total strength of engineering work at Redstone in missiles and in the space area will be greater in the future than it is now with reference to the Army as well as NASA.

COMPLETION OF GUIDANCE AND CONTROL BUILDING

Mr. THOMAS. Now, let us take a look at the completion of your guidance and control building.

At this point in the record we shall insert pages 405, 407, and 408 of the justifications.

(The pages referred to follow:)

COMPLETION OF GUIDANCE AND CONTROL BUILDING

1. Description

It is proposed to construct two separate structures adjacent to and near the existing building No. 4487 as indicated in the drawing on the following page. The main structure will consist of an east extension approximately 50 feet by 500 feet, two floors high, and a south extension approximately 30 feet by 140 feet, one floor high. The second structure will have an irregular-shaped plan and will include a two-story-plus-basement area for a constant azimuth centrifuge, a two-story control room, and an 85-foot high enclosure for an expanded range linear accelerator. Special, closely controlled, air conditioning will be provided for some environmental test areas. The proposed project which will provide approximately 61,000 square feet of floor area, will include the following:

(*a*) Additional laboratories for investigation, research, and development in the fields of inertial, radio, midcourse and terminal guidance. Advanced work is necessary in guidance computers, component evaluation, theory evaluation, and application of present principles of microminiaturization.

(*b*) Laboratories for infrared, optics, and photosensitivity research involving spatial attitude and horizon or light seeking and sensing devices for lunar probes and satellites. In addition to the optical phases of this item, research also must be conducted in the physical relationship and performance of components under simulated spatial attitude conditions.

(*c*) Laboratories and equipment for cryogenics research, investigation, and development. Studies will be undertaken on the performance of materials, components, and devices at temperatures approaching absolute zero and involving superconductivity with respect to microminiaturization, and cryogenic gyros.

(*d*) Laboratories and equipment for solar battery research and application. Special light sources and sensitive measuring devices will be provided for the application and improvement of solar batteries for satellite electrical power use.

(*e*) Laboratories for microwave components and satellite tracking systems research and development. These facilities will be used in the development of tracking transmitters, receivers, antennas, and transponders for tracking systems and space communications.

(*f*) Laboratories and equipment for investigation, research, and development in the field of hydraulic servomechanisms. Flexible hydraulic laboratories and adequate equipment for 5,000 pounds per square inch hydraulic systems such as that required in the SATURN program will be provided. Existing facilities are unsuitable and inadequate. The modernization proposed in this project will not only result in increased capabilities and efficiency but will also vacate high roof facilities necessary for increased capabilities in environmental testing laboratories. The increased environmental testing facilities will include 25,000-pound thrust vibration equipment, shock and impact simulation equipment, and large capacity vacuum and environmental chambers necessary to simulate conditions encountered by space probes and satellites.

(*g*) A separate acceleration test building housing an expanded range linear accelerator and a centrifugal accelerator. The expanded range linear accelerator is a device using a pneumatic method as a working principle and having cycling operation. It will provide the means to subject sensitive components to the influence of linear acceleration. The proposed device will greatly extend the range of linear acceleration tests with respect to peak acceleration, time of constant peak acceleration, and payload weight.

2. Justification

Until recently the mission of the existing guidance and control building was related primarily to military weapons systems with major emphasis on the reliability of surface-to-surface vehicles. With missions now being shifted to pure research and development oriented to payloads, satellites, lunar probes and space vehicles, additional research criteria and requirements have been created. While all existing facilities will be utilized, additional technical capability for investigation, research, and development on problems peculiar to objects being subjected to space travel must be provided. These specialized facilities are required, not only for economy in avoiding trial and error research, but to assure the successful completion of the programs assigned to the NASA Huntsville facility.

3. Cost estimate

Building structure		$1,346,000
Utilities		106,000
Access road		10,000
Research equipment		393,000
Special electrical power	$129,000	
Linear accelerator	98,000	
Centrifuge	104,000	
Cryogenic equipment	40,000	
Hydraulic equipment	22,000	
Laboratory furniture and accessories		31,000
Design and engineering services		62,000
Total estimated cost		1,948,000

4. Construction schedule

Total estimated completion time, 18 months.

Mr. THOMAS. The total cost of this construction is $1,948,000.

Page 408 of the justifications breaks down the cost.

How large is the building which will cost $1,346,000?

General OSTRANDER. It is a 61,000-square-foot building.

Mr. THOMAS. How much is that a square foot?

General OSTRANDER. $22 a square foot.

Mr. THOMAS. What type of construction will it be?

General OSTRANDER. This will be concrete and steel frame with concrete block construction.

Mr. THOMAS. I note that your "Utilities" are in the amount of $106,000; your "Access road" is in the amount of $10,000 and then your "Research equipment" is in the amount of $393,000.

You have an 18-month leadtime for construction.

This also comes under Dr. Hauserman, does it not?

General OSTRANDER. Yes, sir.

Mr. THOMAS. The doctor is in a great big building now.

Mr. OSTERTAG. May I ask a question at this point, Mr. Chairman?

Mr. THOMAS. Surely.

Mr. OSTERTAG. I notice that this item has an 18-month leadtime.

Until that time, what will be used to meet that requirement?

Mr. THOMAS. He will stay in the same building he is in.

General OSTRANDER. This is an addition to the current building they have.

Mr. THOMAS. This is an expansion?

General OSTRANDER. Yes, sir.

Mr. THOMAS. Let us proceed, gentlemen, to the consideration of the next item.

ADDITION TO CHECKOUT BUILDING

Mr. THOMAS. Let us take a look at your request for the addition to the checkout building in the amount of $4.5 million.

At this point in the record we will insert pages 411–1, and 411–3.

(The pages referred to follow:)

ADDITION TO CHECKOUT BUILDING

1. Description

This project provides for the construction and instrumentation of additional facilities for the systems analysis and reliability laboratory. As indicated in the sketch on the following page, the planned addition will consist of a 200-foot extension to the existing checkout building. The addition will be designed to provide the performance test and reliability checkout capability necessary to carry out the recently accelerated SATURN program. A gross area of 110,000 square feet will be provided.

2. Justification

The systems analysis and reliability laboratory will perform a complete checkout of the SATURN booster, including components and subassemblies both before and after static testing of the booster in the test stand. In addition, the checkout of the upper stages and the alinement of the complete system will be performed. By measuring and evaluating performance results and by making corrections where indicated, this function will provide a reliable system and will minimize the possibility of malfunctioning during static test or during actual firing.

An elapsed time of 12 weeks each will be required for prestatic and final checkout. In addition, an estimated 3 weeks will be necessary for preparation of the checkout station to accomplish changes to ground and measuring equipment.

The capability of the existing facility is not more than two SATURN vehicles per year, with a dummy or simplified single upper stage. The proposed facility will provide a checkout capability of four SATURNS per year including presently planned upper stages. Since the present schedule indicates requirements exceeding existing capability early in calendar year 1962 and since the total estimated construction time of the proposed facility is approximately 26 months, fiscal year 1961 funding will be required.

3. Cost estimate

Building		$2,900,000
Heating and air conditioning		127,500
Utilities, including communications		172,000
Site preparation and paving		108,000
Cranes and elevators		97,500
Instrumentation		745,000
Data-processing equipment	$245,000	
Record-processing equipment	40,000	
Laboratory standards	75,000	
Aircraft energizers	108,000	
Cycle alternators	60,000	
Static power supplies	48,000	
Cycle inverters	45,000	
Generators	75,000	
Storage battery cells	54,000	
Design and engineering services		350,000
Total estimated cost		4,500,000

4. Construction schedule

Total estimated completion time, 26 months.

Mr. THOMAS. Your justifications state as follows:

This project provides for the construction and instrumentation of additional facilities for the systems analysis and reliability laboratory. As indicated in the sketch on the following page, the planned addition will consist of a 200-foot extension to the existing checkout building.

How many square feet will be in this building?

General OSTRANDER. This is a checkout building with 110,000 square feet.

Mr. THOMAS. What does this cost per square foot for the building?

General OSTRANDER. $26 a square foot for the building.

Mr. THOMAS. What type of construction is it?

General OSTRANDER. It will be of steel construction, I believe.

Mr. THOMAS. Steel and concrete?

General OSTRANDER. I think this is steel and transite.

Mr. THOMAS. The building costs $2.9 million; heating and air-conditioning costs $127,500; utilities, including communications, $172,000; site preparation and paving, $108,000; cranes and elevators, $97,500; and instrumentation, $745,000.

That is broken down into data-processing equipment in the amount of $240,000; record-processing equipment, $40,000.

What do you mean by this item of "Laboratory standards" in the amount of $75,000?

Then, you have aircraft energizers in the amount of $108,000; cycle alternators in the amount of $60,000; static power supplies in the amount of $48,000; cycle inverters in the amount of $45,000; generators in the amount of $75,000; and storage battery cells in the amount of $54,000.

The leadtime for construction is 26 months.

You are going to pay someone $350,000 to figure out how bad you missed your guess here; are you not?

Dr. DRYDEN. I think in these cases these are the costs of the Army engineering services that you have been talking about.

Mr. THOMAS. Were these cost factors submitted by the Army for this particular project?

Dr. DRYDEN. The design and engineering services costs shown here are the reimbursements to the Army engineers for doing the design and engineering.

Mr. THOMAS. What do they receive? Is that figure 6 percent or 7 percent?

Mr. RHODES. I believe it is between 6 and 7 percent.

Mr. BOLAND. I think it is about 6 percent.

Mr. THOMAS. It is between 6 and 7 percent.

Mr. OSTERTAG. In other words, the Army is reimbursed in this amount?

Dr. DRYDEN. If we use their services, we have to pay for them.

Mr. OSTERTAG. And, you have already used them?

Dr. DRYDEN. Not yet, but we will.

General OSTRANDER. We will give them our basic requirements and they will work up the detailed design and engineering plan.

ATLANTIC MISSILE RANGE

Mr. THOMAS. Gentlemen, let us take a look at your operations at Cape Canaveral, wherein you are requesting $27,750,000.

COMPLETION OF SATURN LAUNCHING COMPLEX

We shall insert pages 413 and 415 of the justification into the record at this point.

(The pages referred to follow:)

COMPLETION OF SATURN LAUNCHING COMPLEX

1. Description and justification

This project includes funds for the construction required to complete the SATURN vertical launch facility No. 34 and for the procurement and installation of collateral equipment. The SATURN facility, originally funded in the fiscal years 1959 and 1960 by the Department of Defense, is presently under construction. The facility will meet the minimum requirements for the research and development phase of the SATURN program. It will provide the capability to launch a 1½-million pound thrust unit with its upper stages and will service vehicles up to 208 feet in total height. The complex will include a staging building, separately funded, to provide assembly area for the handling and mating of upper stages; minimum office space for upper stage contractor personnel; a minimum storage area for upper stage spares and components; and hurricane protection for the booster. A sketch of the launching complex is shown on the following page.

The funds requested in this project will provide for blockhouse equipment and minimum instrumentation for tracking, measuring, and telemetering flight tests; the procurement and final installation of blockhouse checkout equipment; the procurement and installation of collateral equipment required to complete the construction of the SATURN staging building, and necessary design and engineering services.

2. Cost estimate

Procurement and installation of collateral equipment for the staging building	$525,000
Completion of instrumentation sites	100,000
Pad and blockhouse communication and electrical equipment	328,000
Blockhouse and pad maintenance and checkout equipment	360,000
Measuring and tracking equipment	787,000
Design and engineering services	150,000
Total estimated cost	2,250,000

3. Construction schedule

Total estimated completion time, 12 months.

Mr. THOMAS. The leadtime is 12 months, and you state that this project includes funds for the construction required to complete the SATURN vertical launch facility No. 34.

Was there not a launching pad item in your 1960 supplemental involving the expenditure of some funds at Cape Canaveral?

Dr. DRYDEN. Yes, sir; $4 million.

General OSTRANDER. But those funds are not for SATURN stands; they are for the AGENA–B vehicle.

Mr. THOMAS. You are constructing a new stand there?

Mr. ULMER. The 1961 program includes $2,250,000 to complete a SATURN launching complex currently under construction and $21 million for a new SATURN launching complex; the 1960 supplemental funds will be used to modify an existing stand for use with the AGENA–B vehicle.

Mr. THOMAS (reading):

The complex will include a staging building separately funded.

Where is it funded?

General OSTRANDER. It is shown further on, on page 415–15.

Mr. OSTERTAG. Is this at Canaveral?

General OSTRANDER. It is all at Canaveral.

HYDROGEN SYSTEM

Mr. THOMAS. There is a little item on 415–4 and 5. Put that in the record.

(The pages referred to follow:)

HYDROGEN SYSTEM

1. Description and justification

Large quantities of liquid hydrogen will be required for SATURN upper stages. Because of its low-boiling point and high flammability, special handling and storage techniques are necessary. Tank trucks will transport liquid hydrogen to the launch site from a generating plant 160 miles distant. The need for a closed-cycle loading system dictates the requirement for storage and transfer facilities at the launching complex currently under construction. Explosion-proof wiring, vacuum insulation of the storage tanks, and remote control of the fueling operation from the blockhouse are required.

Service tower modifications will also be required, including the installation of explosion-proof wiring and hydrogen venting capabilities. These features are not included in the structure currently under construction.

2. Cost estimate

Hydrogen storage	$440,000
Evaporation system and helium heat transfer system	176,000
Liquid nitrogen cooling system	296,000
Fuel and vent lines	484,000
Vacuum systems	304,000
Oxygen trace indicator	39,000
Computer and local control station	110,000
Blockhouse indicator and control station	139,000
Site development	87,000
Service tower modifications	182,000
Valve fittings and control apparatus	63,000
First H_2 fill, installation, and testing	120,000
Venting and disposal system	60,000
Total estimated cost	2,500,000

3. Construction schedule

Total estimated completion time, 18 months.

Mr. THOMAS (reading):

Large quantities of liquid hydrogen will be required for SATURN upper stages. Tank trucks will transport the liquid hydrogen to the launch site from the generating plant 160 miles away.

Where is that plant located?

Mr. HORNER. West Palm Beach.

Mr. THOMAS. Who operates that?

Mr. HORNER. Air Products.

Mr. THOMAS (reading):

The need for a closed-cycle loading system dictates the requirements for storage and transfer facilities at the launching complex currently under construction. Explosion-proof wiring, vacuum insulation of the storage tanks, and remote control of the fueling operation from the blockhouse are required.

Service tower modifications will also be required including the installation—

Do you have one there now or is this a brandnew one?

General OSTRANDER. The service tower has to be modified because we have recently made the decision to go to the liquid hydrogen propellant for the upper stages.

Mr. THOMAS. Is this modernization money or is this construction from the ground up?

General OSTRANDER. On the hydrogen system, this is a complete hydrogen storage and loading system.

Mr. THOMAS. This is brand new?

General OSTRANDER. Yes.

Mr. THOMAS. Do you have a duplicate of this?

General OSTRANDER. Not a hydrogen system.

Mr. ULMER. This is the system for the stand now under construction?

General OSTRANDER. That is right.

Mr. THOMAS. Regardless of the cost of this, you have to have it, do you not?

Mr. ULMER. Yes, sir.

Mr. THOMAS. Your alternative to spending this $2½ million is to transport it and take a chance on getting it that 160 miles when you need it, is that it?

General OSTRANDER. We simply would not be able to load it from tank trucks as it came in from the plant directly into the missile. We have to have provisions for storing it.

Mr. THOMAS. When it is delivered to you by tank, what is the temperature of it?

General OSTRANDER. Minus 423°.

Mr. THOMAS. What is the nature of the transport tanks?

General OSTRANDER. It is an insulated, I believe, stainless steel tank.

Mr. THOMAS. How long would it last in the tanks? Suppose you were delayed in the use of it 24 hours, could it stay in the tanks 24 hours?

General OSTRANDER. It would boil off. I do not know the exact rate of boiloff, but we would lose a certain amount of it.

Dr. SILVERSTEIN. We are currently taking hydrogen across the country in trailers and with the loss of 10 percent on a trip across the country.

Mr. THOMAS. You are taking this 160 miles. How much loss would there be to let it stay in the tank 12 or 15 hours? Suppose you had a mishap and you had to delay 18 or 24 hours.

Mr. HORNER. Mr. Chairman, I think more important is—we are talking about one servicing here of as much as 120,000 pounds. It would take a fairly long row of tank cars to haul that.

Mr. THOMAS. How much do you transport by one tank car? What is it transported by, trucks or tank trucks?

Dr. DRYDEN. Tank trucks.

Dr. SILVERSTEIN. 120,000 pounds is a little over 200,000 gallons of liquid hydrogen.

Dr. DRYDEN. What are the tanks used in transport across country now, 5,000 gallons?

Dr. SILVERSTEIN. Yes.

Mr. THOMAS. You use how many truckloads in one firing?

Dr. DRYDEN. Forty truckloads in one firing.

Mr. HORNER. It would be completely impractical to unload from 40 trucks into one missile for one firing.

Mr. THOMAS. What is the unit cost of this? Do you buy it by pounds or gallons?

Dr. SILVERSTEIN. Pounds.

Mr. THOMAS. What is the unit cost?

Dr. SILVERSTEIN. It will be, at this level, around 25 cents a pound. This is a guess because we have not brought it in this quantity before.

Mr. THOMAS. What is the nature of this construction?

General OSTRANDER. In the hydrogen system it consists largely of insulated storage facilities for the hydrogen and for pumping facilities to actually load the hydrogen into the upper stages of the missile.

Mr. THOMAS. How thick are the walls? Do you use reinforced steel with a couple of dead-air spaces in there? What is the nature of the construction?

General OSTRANDER. The tanks themselves are made of stainless steel. I believe they are insulated with a——

Dr. DRYDEN. This has a vacuum-type system like a thermos bottle.

Mr. THOMAS. A couple of walls and dead space. Is it steel or concrete?

Dr. DRYDEN. Steel.

Mr. THOMAS. How many of these tanks will you build?

Dr. DRYDEN. Do you know whether this is a single tank? I do not recall.

General OSTRANDER. I don't know the total capacity.

Mr. THOMAS. These figures do not mean anything to you and they do not mean anything to us, do they? It will take 18 months to build it. What will you do in the meantime?

Dr. DRYDEN. We have considerable backup data for this. It is a question of how much to bring into the committee room. It is awful hard for a person to remember all of it. We can get any of it that you want.

Mr. THOMAS. Can you tell us what your construction cost a square foot is, how big your tanks are, and how many of them you will have?

Dr. DRYDEN. I do not believe that this is located in the building at all. They usually build tanks outdoors like gasoline storage tanks, sitting up on a concrete wall.

Mr. THOMAS. How many tanks will there be?

Dr. DRYDEN. I am sure there will be more than one. It would be foolish to put all of this material in a single tank.

Dr. VON BRAUN. On page 414, it is shown what is intended to do.

Mr. THOMAS. Have we ever built one of these?

Dr. VON BRAUN. Smaller tanks of this kind have been built. This illustration shows it.

Mr. THOMAS. Do you have one at Huntsville?

Dr. VON BRAUN. No, sir.

Mr. THOMAS. Where is one in existence?

Dr. VON BRAUN. There is a small one in existence at the Pratt & Whitney plant at West Palm Beach.

Mr. THOMAS. Is it a pilot plant?

Dr. von BRAUN. No. It is sizable, quite sizable. They use it for the development of the CENTAUR engine. The liquid hydrogen tank pumps the liquid hydrogen into that tank and they take it out as they need it for the test.

You see the facility here. Here is a big storage tank and this is the vacuum-jacketed fueling line going up to the missile site.

Mr. THOMAS. Is this all underground storage?

Dr. VON BRAUN. No, sir; overground storage and the pipe is also overground, with the exception of the pad area itself.

NEW SATURN LAUNCHING COMPLEX

Mr. THOMAS. The new SATURN launching complex will be $21 million. Put pages 415–6, 12, and your cost estimates on 415–13 and 14 in the record.

(The pages referred to follow:)

NEW SATURN LAUNCHING COMPLEX

1. Description

This project provides for the construction of a second, completely independent, SATURN launching complex at the Atlantic Missile Range. The proposed new complex will provide a backup for the facilities presently under construction and a capability for increased firing rates. The proposed location for a new complex is north of the SATURN complex now under construction. Plot plans and sketches of the facilities proposed for construction under this project are shown on the following five pages.

Blockhouse.—The blockhouse will be a concrete igloo-type structure for the protection of personnel and instrumentation during test firings. The dome will be constructed of reinforced concrete 5 feet thick covered with 7 feet of fill dirt and an additional 4 inches of concrete to provide protection against extremely high blast pressures. Visual observation will be provided by two periscopes, protruding from the top of the dome.

Launch service structure.—The service structure will provide a means of erecting the missile on the launch pedestal in stages. It contains platforms for servicing and checking out the stages prior to launch. The service structure will be approximately the height of a 30-story building. It will be retractable to a rear parking area during firings. The bridge cranes will lift and position any of the stages of the SATURN vehicle. In the lower two floors of the structure, enclosed space will be provided for instrumentation and checkout of the missile.

Umbilical tower.—The umbilical tower will carry fuel lines and power to the missile during checkout and prelaunch phases. Shortly before launching, the fuel and powerlines will be disconnected and the unbilical arms swung out of the way of the vehicle's path.

Pad and area development.—This item includes clearing and preparing the area for facilities installation; the construction of concrete work in the pad area, including the launch pad and pedistal, subpad rooms to house special instrumentation, revetments for the protection of propellent storage facilities, and concrete roads within the complex; and extending base utilities such as water, electrical power, and communications to the pad area.

Fuel, liquid oxygen, and high-pressure gas facilities.—Permanent storage and pumping facilities are required to provide fuel and liquid oxygen for the SATURN booster. Liquid oxygen storage capacity of 1,200,000 pound will be provided by a 41-foot-diameter sperical tank. A smaller 13,000-gallon tank will be used for topping. The fuel storage facility will contain two 28,000-gallon fuel tanks. High-pressure gas will be used in pressurizing the tanks.

Liquid hydrogen facility.—The quantities of liquid hydrogen needed for SATURN upper stages will require a permanent storage and transfer system for proper handling.

Ground-support equipment.—This item will provide for long leadtime capital items of electrical, mechanical, and electronic equipment for vehicle checkout, handling, and launch control.

2. Justification

The importance to the Nation of the SATURN program and the urgency of attaining desired goals have led to an alteration of certain concepts of operation at the launch site. In particular, recent specific guidelines concerning missions and schedules have permitted establishment of more firm requirements; and recently acquired information concerning blast effects of vehicles which explode during launch, has had considerable impact upon earlier concepts.

In brief, blast studies have established that the booster fuel load of 750,000 pounds could be considered equivalent to 10 percent of this weight in TNT, and that damage to the pad and associated facilities from an explosion of this magnitude would require approximately 1 year to repair. This finding obviously indicates the need for a second pad to insure maintaining schedules with a higher firing rate than one per year. A second consideration was to determine the minimum distance between pads to prevent damage to one missile from another which explodes on an adjacent pad. The study determined this distance to be approximately 4,000 feet. The time for checkout of complex SATURN vehicles will require that two missiles be worked on at the same time to meet firing schedules. Hence the second finding outdates the previous practice of providing common facilities for two pads; distances between pads will exceed tolerable runs for measuring leads and propellant lines. It is therefore apparent that a second, completely independent backup launch complex is necessary to support the planned SATURN development schedule.

3. Cost estimate

Blockhouse		$1,675,000
Service structure		8,150,000
Railroad and anchor	$1,150,000	
Steel structure	3,100,000	
Moveable platforms	600,000	
Elevators	280,000	
Bridge crane	600,000	
Traction equipment	900,000	
Air conditioning and heating	150,000	
Communications and electrical system	670,000	
Miscellaneous mechanical equipment	230,000	
Enclosures	170,000	
Personnel escape mechanism	300,000	
Pad and area development		7,675,000
Launch pad and pedestal	1,520,000	
Site preparation and roads	965,000	
High-pressure gas system	900,000	
High-pressure water system	840,000	
Electrical distribution system	600,000	
Communications cabling	275,000	
Utilities and domestic water	125,000	
Extension of base utilities	2,450,000	
Umbilical tower		850,000
Fuel and oxygen storage facilities		900,000
Liquid hydrogen facility design		250,000
Ground support equipment		1,500,000
Total estimated cost		$21,000,000

Items to be deferred include such items as servicing equipment for hydrocarbon fuel, liquid hydrogen, liquid oxygen, liquid nitrogen, and short leadtime instrumentation. Approximately $8 million will be required to complete the equipment and activation of this facility in the fiscal year 1962.

4. Construction schedule

Total estimated completion time, 18 months.

Mr. THOMAS. (reading):

This complex provides for the construction of a second, completely independent, SATURN launching complex at the Atlantic Missile Range.

Is there a complete one in existence there now?

Mr. ULMER. It is being built now.

General OSTRANDER. The one you looked at earlier will be completed with funds this year.

Mr. THOMAS. What did that cost?

The proposed new complex will provide a backup for the facilities presently under construction and a capability for increased firing rates. The proposed location for the new complex is north of the SATURN complex now under construction.

What was your answer, General? What would be the cost of it?

General OSTRANDER. Of this complex, sir?

Mr. THOMAS. No, the one under construction.

General OSTRANDER. The total cost is something in the neighborhood of $21 million, I believe.

Mr. OSTERTAG. That includes everything?

Mr. THOMAS. That is the estimated cost on this one. Do you have any reasonable cost estimates on the one that is under construction now? How far along is it? When will it be completed?

General OSTRANDER. The total estimated cost of the complex now under construction is $21 million. It is about 75 percent complete. It will be complete in January of 1961. Our first firing on it will be the third quarter of calendar year 1961.

Mr. THOMAS. This is a backup.

General OSTRANDER. This is a backup, and to take care of the anticipated increased firing rate.

Mr. THOMAS. What is the completion date on this second one?

Dr. DRYDEN. About 18 months.

Mr. THOMAS. Eighteen months.

The items to be deferred include such items as servicing equipment for hydrocarbon fuels, liquid hydrogen. Approximately $8 million will be required to complete the equipment and activation of this facility in 1962.

It will be around $29 or $30 million rather than the $21 million.

Dr. DRYDEN. That is right.

Mr. THOMAS. What additional facilities will this have that you do not have at the one you are building now?

General OSTRANDER. The new complex will be designed to take the follow-on SATURN vehicles with the four to five stages. Because of safety considerations, we have to build the new facility in an area north of the present land area at the cape, which is completely undeveloped, so that we have additional utilities costs.

Mr. THOMAS. How far is it away from your existing one? It cannot be more than half a mile, can it?

General OSTRANDER. You can see on the plot plan on page 415–7, the location with respect to the present launch.

Mr. THOMAS. How far is it away?

General OSTRANDER. As I remember, it is a little over half a mile from the present one.

Mr. THOMAS. Your blockhouse is $1,675,000. How many square feet are there in your blockhouse? What do you need with a separate blockhouse if it is a half mile from the other one?

General OSTRANDER. There are two reasons: First, the present blockhouse simply won't take the equipment we need, and second, if we attempted to use the present blockhouse, the lines, the instrumentation lines running to the new complex, would be so long that we couldn't get accurate instrumentation readings.

Mr. THOMAS. It is not half a mile away, is it? Is that too far away?

General OSTRANDER. Yes, sir.

Mr. THOMAS. You canot use your present one.

How many square feet are there in this blockhouse?

Dr. DRYDEN. It is a beehive shaped structure.

General OSTRANDER. I do not have that figure. I can get it for you.

Mr. THOMAS. Who is going to do this construction job?

General OSTRANDER. This also will be done under the Corps of Engineers by private contractors.

Mr. THOMAS. The Corps of Engineers will superintend it and it will be let by competitive bid like the corps usually operates.

Mr. OSTERTAG. Do they let the contract, or you?

General OSTRANDER. The corps will.

Mr. THOMAS. Gentlemen, will the committee come to order?

STAGING BUILDING

Mr. THOMAS. Let us take a look at the staging building at the Atlantic Missile Range.

This project provides for the construction of a staging building required for the assembly, handling, and mating of SATURN stages. It will provide office and laboratory spaces for upper stage contractors, storage area for spares and components, and hurricane protection for all stages, including the booster. It will contain complete checkout equipment for subassemblies as well as for individual stages.

How large will this building be?

General OSTRANDER. This is 25,500 square feet.

Dr. DRYDEN. It is a hangarlike structure.

Mr. THOMAS. What does it figure out a square foot?

General OSTRANDER. About $28 a square foot. The primary cost on this is this high bay area that we have in it.

Mr. THOMAS. Air conditioning, plumbing, $220,000; bridge cranes, $330,000.

What is the nature of the construction? Is it concrete and steel?

General OSTRANDER. This is concrete and steel frame, I believe, concrete block walls.

Mr. THOMAS. Does it have any offices?

General OSTRANDER. I think there are a few offices in these lean-to's.

Mr. THOMAS. How high will the center of the building be?

Mr. ULMER. About 50 feet.

Mr. THOMAS. From the ground to the roof, all the way?

Dr. DRYDEN. Yes, sir. This picture shows it.

It is a hangarlike building.

ADDITION TO ENGINEERING AND LABORATORY BUILDING

Mr. THOMAS (reading):

This project describes the need for an extension to the existing engineering and laboratory building to provide an additional 11,000 square feet of usable engineering area. A sketch of the proposed two-story building is shown on the following page.

This is a small item of $300,000.

Put pages 416 and 418 in the record.

The building itself will cost $157,000. There are 11,000 square feet. How much is that?

(The pages referred to follow:)

ADDITION TO ENGINEERING AND LABORATORY BUILDING

1. Description

This project describes the need for an extension to the existing engineering and laboratory building to provide an additional 11,000 square feet of usable engineering area.

2. Justification

The combined demand for laboratory, hangar, and engineering space available to the NASA Huntsville facility's missile firing laboratory at Cape Canaveral are already overtaxing available space. The increased workload associated with the Juno II and Mercury programs is further aggravating this situation. By the time the full impact of the SATURN program is assimilated, additional space will be essential if the exacting standards of operation teamwork and hardware preparation so necessary to successful launch operations are to be maintained.

For lack of specialized engineering space existing personnel are being temporarily housed in laboratory and hangar space and in trailers. This arragement impairs efficiency and undermines operational control since personnel whose efforts must be closely integrated are spread over a considerable area. Furthermore, the imperative need for additional space to store, inspect, and set up the increasing volume of vehicle components, and the checkout and handling equipment associated with these advanced programs, most particularly SATURN, requires either the complete evacuation of these personnel or the construction of additional laboratory and hangar space. The proposed provision of additional engineering and administrative space is decidely the cheaper solution and will enable an efficiently organized operation.

3. Cost estimate

Building	$157,000
Air conditioning	64,000
Electrical installations	53,000
Fire alarm	9,000
Design and engineering services	17,000
Total estimated cost	300,000

4. Construction schedule

Total estimated completion time, 12 months.

General OSTRANDER. $14 a square foot.

VARIOUS LOCATIONS

TRACKING FACILITIES

Mr. THOMAS. You are getting into some big money in your "Tracking facilities," $27,500,000.

At this point, Mr. Reporter, put the table beginning on pages 424, 425, and 426 in the record.

(The pages referred to follow:)

2. Cost estimate

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1960, supplemental	Fiscal year 1961
MINITRACK NET				
Station development and construction:				
Initial site development	$25,000			
Station construction	70,000	$784,000		$450,000
Buildings and utilities		777,000		
Tracking and data acquisition equipment:				
New electronic equipment, antenna arrays, and receivers		1,144,000		
Modification kits		1,000,000		
Telemetry equipment		500,000		
Data-acquisition antennas				400,000
Tracking filters and new minitrack electronics				300,000
Command transmitters and modifications, and calibration antennas				100,000
Wide-band data-acquisition equipment				200,000
High-gain antennas and special equipment for meteorology and precision tracking				600,000
Optical components				250,000
Portable electronic ranging and support equipment				950,000
Special equipment for calibration and timing				300,000
Data processing and handling equipment:				
Automatic data read-out units				500,000
Data receiving, recording, and conversion units				700,000
Total, minitrack net	95,000	4,205,000		4,750,000
DEEP SPACE NET				
Station development and construction:				
Construction of permanent technical facilities				1,300,000
Construction of permanent support facilities				1,700,000
Tracking and data acquisition equipment:				
Initial Woomera receiving equipment and installation	1,547,000	1,500,000		
Initial South Africa receiving equipment and installation		2,000,000		
Goldstone transmitting equipment and installation	1,003,000			
Improved receiving and tracking support equipment				3,000,000
Initial trajectory measurement equipment and facilities				1,000,000
Data processing and handling equipment: Data processing equipment for tracking and telemetry				1,000,000
Total, deep space net	2,550,000	3,500,000		8,000,000
MERCURY NET				
Station development and construction:				
Initial site development		2,700,000		
Station construction			$2,245,000	2,400,000
Power generators and equipment shelters		1,900,000	690,000	
Ship modifications		2,000,000		
Tracking and data acquisition equipment: Procurement of long lead time radar equipment	2,425,000			
Precision radar systems		1,750,000		
Accessory equipment for radars		5,000,000		
Precision radar support equipment		2,500,000	590,000	
Active acquisition aids		1,900,000		
S-band radar equipment			250,000	400,000
Seaborne radar and stabilization equipment				1,200,000
Radar accessory and modification equipment				500,000
Data processing and handling equipment:				
Digital data handling and telemetry equipment		1,500,000		
Command transmitter and vehicle communications equipment		1,345,000		
Telemetry recording and data handling equipment		2,000,000		
Data transmission equipment		3,300,000		
Communications and computer equipment		3,100,000		
Extension and improvement of ground communications equipment				1,500,000
Vehicle to earth communications equipment				1,000,000
Telemetry and radar data processing and display equipment			1,425,000	2,800,000
Demonstration, test, and checkout equipment:				
Test and checkout of station equipment				3,000,000
Special test equipment			1,800,000	2,200,000
Total, MERCURY net	2,425,000	28,995,000	7,000,000	15,000,000
Total, estimated cost	5,070,000	36,700,000	7,000,000	27,750,000

Mr. THOMAS. These show for 1959 you spent $5,070,000 for the tracking system, $36,700,000 for 1960, and you want $27,750,000 this year.

This is construction money. Over in R. & D. for operations you have another item for your tracking systems of $32 million. How many did you take over that were not accounted for from the IGY? Was it 14, 15, or 17?

Dr. DRYDEN. Do you have the number of minitrack stations?

Dr. SILVERSTEIN. We will have a total of 14 at the end of this year. We took over 11 and canceled 1, leaving 10. We have added four.

Mr. THOMAS. For fiscal year 1961, counting your construction costs and at least a fair value for those you took over, plus your operation cost, how much money have you got tied up in stations for fiscal year 1960?

Is it around $92 or $95 million?

Dr. DRYDEN. Pretty close to that; yes, sir.

Mr. THOMAS. Mr. Reporter, put pages 419 through 423 in the record at this point.

(The pages referred to follow:)

TRACKING FACILITIES

1. Description and justification

This project covers improvements to be made to existing tracking facilities by the addition of basic tracking, data acquisition, communications, and computing capability essential to the accomplishment of new and more complex missions. Major objectives of the 1961 program include:

(*a*) Construction of special meteorological data acquisition equipment and improved tracking equipment.

(*b*) Continued improvements and modifications to the minitrack stations.

(*c*) Establishment of a new portable optical tracking equipment.

(*d*) Establishment of new initial trajectory tracking equipment for deep space vehicles.

(*e*) Establishment of flexible receiving capability at new deep space stations for various frequencies.

(*f*) Improvement of facilities and data handling capability at deep space stations.

(*g*) Completion of instrumentation and construction of Project MERCURY tracking stations.

A more detailed discussion of the proposed improvements follows:

Facilities for satellite electronic and optical tracking (minitrack net).—At the beginning of the fiscal year 1961 there will be 14 minitrack electronic satellite stations at the following locations: Blossom Point, Md.; San Diego, Calif.; Fort Myers, Fla.; Antigua Island, West Indies; Quito, Educador; Lima, Peru; Antofagasta, Chile; Santiago, Chile; Woomera, Australia; Esselen Park, South Africa; Newfoundland; Fairbanks, Alaska; East Grand Forks, Minn.; and England. The station in England will not be operational until the last quarter of 1960. These stations will aid in the tracking of satellites in high inclination orbits and of polar orbiting satellites and will have been adapted to the new tracking frequency of 136–137 mcs. by the end of the fiscal year 1960. Improvements are required in automatic read-out equipment to expedite data collection and to permit the tracking of a greater number of satellites.

As more satellites are launched and remain in orbit, automatic data-read-out equipment will be needed for the minitrack stations to permit more rapid data collection, and to permit the simultaneous tracking of the greater number of satellites in orbit. Data acquisition antennas will be procured for five stations for receiving greater quantities of data. New data recording and conversion units will be procured for telemetry purposes. Improvements will also be made in the telemetry receivers to accommodate the transmissions of data from new and more complex satellite payloads. Command transmitters will be modified and up-dated to meet the requirements of new satellites.

Meteorological satellites to be launched in the fiscal year 1961 will incorporate instruments for transmitting considerable more complex information than is

generated by most other types of satellites. This additional complexity is comparable to the difference between transmissions of information of a few words at a time and transmissions of whole sentences or paragraphs of information at a time. Technically, the acquisition of complex information from satellites, such as the cloud cover television pictures which will be transmitted from meteorological satellites, requires wide bandwidth receiving systems on the ground.

At present, use is being made of non-NASA facilities at Deal, N.J. and Kaena Point, Hawaii on a reimbursable basis. Although these stations have certain capabilities (high-gain antennas) for meteorological satellites, they were not designed for this use and are available to the meteorological program on a time-sharing basis only. While these stations will serve the needs of the meteorological program during early exploratory tests, it is necessary that NASA develop, on a full-time basis, data acquisition and display devices and techniques which will serve as prototypes when turned over to an operating agency. The equipment to serve this purpose will consist of a high-gain antenna with supporting wide band receivers, recorders, and data display devices. This equipment will be originally located at Blossom Point, Md., one of the minitrack sites. Adequate land is available and it is readily accessible to NASA and Weather Bureau scientists who are carrying out the meteorological program. As the program progresses, this equipment will be redeployed to other minitrack sites if expansion of world coverage is found necessary. Concurrently this equipment can be utilized in the planned installation of a more precise tracking system which will be inherently more accurate than the present minitrack system. A more accurate tracking technique is needed for future measurements in scientific programs.

The existing 12 Baker-Nunn optical stations, which are permanent tracking camera installations installed and operated by the Smithsonian Astrophysical Observatory, are located as follows: Hobe Sound, Fla.; Curacao, N.W.I.; Arequipa, Peru; Villa Dolores, Argentina; Olifantsfontein, South Africa; Cadiz, Spain; Shiraz, Iran; Naini-Tal, India; Woomera, Australia; Mitaka, Japan; Haleakala, Hawaii; White Sands, N. Mex. It is contemplated that additional optical sites consisting of mobile, nontracking type cameras will be needed for geodetic satellites. These cameras will be used to provide the highly accurate data needed for determining the relative location of various land masses with the aid of satellites. Photographing the satellite in relation to known star positions can give accuracies of a few seconds of arc. The cameras will be moved periodically to new sites where new measurements are to be made to acquire the necessary map data. It is contemplated that these stations will have electronic ranging capability, command capability, and timing telemetry capability.

Facilities for deep space stations (deep space net).—The tracking and reception of telemetry data from space probes require the provision of special, highly sensitive receiving systems located at several points on the earth's surface. These stations also provide a potential means for wide bandwidth data reception. Each station will ultimately consist of two separate 85-foot parabolic antennas, one for transmitting and one for receiving signals. Associated with each is the supporting electromechanical equipment for controlling the antenna and the electronic receiving equipment and transmitting equipment.

The minimum requirement in connection with deep space vehicles is for three tracking stations spaced about 120 degrees apart on the earth's surface. These stations must be in locations where there is little or no electrical disturbances from other activities to interfere with the faint signals received from space vehicles. The JPL facility at Goldstone (Camp Irwin), Calif., is the only currently operational deep space station. It is expected that a second station in Woomera, Australia, will be operational during the fiscal year 1960. A third station in South Africa is scheduled to be completed during the fiscal year 1961. The NASA will continue to make use of the Jodrell Bank 250-foot antenna station in England on a cooperating basis. Substantial portions of the receiver equipment for 960 mcs were purchased for Australia and South Africa in the fiscal year 1960.

The three stations have programed an operational capability for reception at only a single frequency (960 mcs). It is necessary to increase this minimal receiving capability to several other frequencies (136 mc, 183.6 mcs, 378 mcs, 225–260 mcs) in order to meet the requirements of the NASA lunar and satellite programs and for special requirements.

The stations will also require improved data handling equipment to provide a capability for processing large quantities of tracking and telemetry data

automatically. This will improve the accuracy, reliability, and capacity of the network. Such capability will also permit more rapid relay of data between the stations in the network. These improvements will facilitate the use of these stations for handling lunar probes, communication satellites, meteorological satellites, highly elliptical scientific satellites, and for certain other special applications.

Except for some technical facilities programed for Woomera, the other stations in the deep space network have no permanent technical, utility, or support facilities. Technical and utility facilities such as permanent control buildings, roads, air conditioning, water, sewage, antenna feed servicing tower, and fuel storage are required to insure reliable operation. Since there are virtually no back-up type facilities available, efforts must be made to insure continuous operation over extended periods of time despite climatic condition or utility variations. In like manner, the operational staff will require permanent housing, mess, and administration facilities. For illustration, the lunar hard landing mission planned for 1961 would require each station staff to operate almost continuously for approximately 1 month.

Lastly, a facility is required to track deep space vehicles very precisely during the first portion of flight close to the earth, but beyond the launching range instrumentation, in order to provide the data necessary to point initially the 85-foot dishes. This facility will possess high tracking rates (six times those of the 85-foot dish) and precision ranging equipment necessary to establish a semidefinitive orbit in a short time period. The location of such a facility is dictated by the trajectory employed since the powered flight is interrupted and a period of coasting allowed. During the coast period the vehicle will generally leave the the area covered by the range instrumentation. Therefore, when the final portion of powered flight is initated, more tracking data must be obtained to ascertain the new trajectory. This initial trajectory tracking station will be colocated with the South African station but installed in a manner permitting relocation if new types of trajectories are later selected. Since the station tracks the payload signal, the majority of the equipment is designed for the 960-megacycle band. Funds will be used for the procurement and installation of antennas, servos, feeds, transmitter, and ranging equipment. It is expected that advanced projects in the future will require additional facilities of this type.

Facilities and equipment for support of manned space flight (Mercury net).—Proper execution of the manned satellite program requires the installation of various tracking radars, acquisition equipment, telemetry equipment, communications equipment, and many associated items. A belt of approximately 16 stations encircling the earth is being established to insure means for safe injection into orbit, midcourse tracking and communication, and precision determination of reentry and impact point. Great emphasis must be placed on assuring recovery of the vehicle. Therefore, a high order of reliability is necessary. Backup equipments and systems are employed to increase reliability.

The work to be done under this project includes completion of station construction tasks, particularly affecting the ship stations and Australian and African stations.

Additional electronic tracking equipment and services remaining to be procured consists of modifications on S-band radar equipment for the U.S. mainland; a seaborne radar tracking equipment together with stabilization equipment for installation aboard a ship in the southern California area in the event of such a requirement; and radar accessory and modification equipment, requirements for which cannot be fully determined prior to early demonstration tests.

Additional requirements for data processing and handling equipment includes computer and communications equipment for data handling; extended and improved ground communications to obtain high reliability, especially in the United States to Bermuda links where initial orbit conditions are most critical; additional communications items for the vehicle-to-earth link; and telemetry and radar data processing and displays which will be augmented, based on demonstration and tests of early prototypes now being purchased.

Mr. THOMAS (reading):

This project covers improvements to be made to existing tracking facilities by the addition of basic tracking, data acquisition, communications, and computing capability essential to the accomplishment of new and more complex missions. Major objectives of the 1961 program include—

It is not only improvements, but it is building from the ground up of a good many brandnew ones and powerful ones.

(a) Construction of special meteorological data acquisition equipment and improved tracking equipment.
(b) Continued improvements and modifications to the Minitrack stations.

Are they your old stations, the low range?

Dr. DRYDEN. The frequencies which were assigned during IGY were temporary—108 megacycles. The frequency allocated for the permanent use of Minitrack stations is 136–137.

Mr. THOMAS. Basically, what is the difference between these old Minitrack stations and the new ones you want to build?

Dr. DRYDEN. There are no new stations in here, are there?

Mr. THOMAS. Yes, there are plenty of them.

Dr. SILVERSTEIN. There are four new stations.

Dr. DRYDEN. Not in this budget. They were built in previous budgets.

Dr. SILVERSTEIN. Equipment modifications are still occurring in this budget.

Mr. THOMAS. I am talking about the whole program, not just the Minitrack stations. You are building 12 or 15 new ones.

Dr. SILVERSTEIN. If I may review them, there are three nets, the Minitrack net, the MERCURY net, and the third one is the deep space net. Now, we have some 14 stations in our Minitrack net, distributed around the world, which do satellite tracking, low-altitude tracking at a frequency of about 136 megacycles. The deep space net has three principal stations, one in Goldstone, Calif., one at Woomera, Australia, and one at South Africa.

Mr. THOMAS. Are they in operation now?

Dr. SILVERSTEIN. No, sir. Just one of them is in operation now.

Mr. THOMAS. That is the one in California?

Dr. SILVERSTEIN. Yes, sir.

The third net is the MERCURY net which is currently being installed and it will have 16 active tracking stations, plus 2 other stations, a command station and a communication data control center.

Mr. THOMAS. How many units are there in the MERCURY tracking, 16?

Dr. SILVERSTEIN. There are 16 tracking units, but 2 additional stations that are part of the net, making 18 in all.

Mr. THOMAS. How many of those are under construction?

Dr. SILVERSTEIN. They are all under construction in one form or another.

Some are coming out earlier than others.

The program has been designed so that the net will have the capability required for our short early flights and for the later flights it will have the full capability.

Mr. THOMAS. What part of this $27,750,000 will be used to construct new stations and where will they be constructed?

I thought all your MERCURY stations were practically new and you would not use this money for that.

Dr. SILVERSTEIN. They are. Part of the work had been started in previous budgets.

In the supplemental budget $7 million was requested to maintain scheduled construction rate.

Some $15 million of this money is to finish the MERCURY net.

Dr. DRYDEN. $2,400,000 is for station construction.

Mr. THOMAS. Will this amount complete all your stations or is this another downpayment?

Dr. DRYDEN. There may be some additional requirements—the Woomera station was financed completely in 1959 and 1960. Funds for the South Africa station were appropriated in 1960.

Mr. THOMAS. My justification does not have that good information.

Dr. DRYDEN. It is in the table showing the moneys in 1959 and 1960 and 1961. If you will read on page 425 under tracking and data acquisition equipment "Initial Woomera receiving equipment and installation," $1,547,000 in 1959 and $1,500,000, 1960, nothing in the supplemental, or 1961.

Mr. THOMAS. Does this complete it in 1960?

Dr. DRYDEN. It completes its capability except for such continuing capital improvements that may be required.

Mr. THOMAS. How many are there in the deep space net?

Dr. DRYDEN. Three stations.

Mr. THOMAS. One of them is in existence now in California?

Dr. DRYDEN. That is right.

These are stations with antennas 85 feet in diameter.

As far as the minitrack net is concerned, there is one item of station construction, $450,000.

Dr. SILVERSTEIN. Yes.

Dr. DRYDEN. The rest of the items are equipment, data acquisition antennas, tracking filters, new electronic equipment, etc. All of these stations are being equipped so they can send command signals to satellites.

Mr. THOMAS. Can anybody break down this $27,500,000 into new construction, then into your component parts, and then what part you are using to complete construction heretofore started? Is that available? This table is very good, but it will take a couple of weeks to go into the table.

Dr. SILVERSTEIN. I think I can break it down. I think $3,450,000 of this could be classified as new construction of buildings.

Mr. THOMAS. Where are they located?

Dr. SILVERSTEIN. The $450,000 is part of the minitrack net, the $1.3 million plus the $1.7 million shown on page 425——

Mr. THOMAS. That is in the deep space?

Dr. SILVERSTEIN. Yes. That is for Australia, South Africa, and California.

Mr. THOMAS. You say "construction." What kind of construction is that, housing or buildings?

Dr. SILVERSTEIN. Permanent buildings at these stations to house equipment and the people and to provide for continuous operations.

Mr. THOMAS. That is $3 million.

Dr. SILVERSTEIN. Yes.

Mr. THOMAS. That is $3.4 million for buildings.

Dr. SILVERSTEIN. $3 million for the deep space net.

Mr. THOMAS. $3.4 in total. In your deep space, you have $3 million.

Dr. SILVERSTEIN. The MERCURY group is next, and the item shown here is $2,400,000 under station development and construction.

Mr. THOMAS. Is that all buildings?

Dr. SILVERSTEIN. There are buildings to house the technical equipment and in some cases to take care of the people who have to stay at these remote sites.

Mr. THOMAS. Your minitrack is $3.4 million. At how many stations do you spend that amount of money?

Dr. SILVERSTEIN. The $450,000 was the figure that I had for the minitrack; the $3.4 million included also the deep space net. The $450,000 really is based on one site. That is the number shown on page 424.

Mr. THOMAS. That is only $454,000.

Dr. SILVERSTEIN. Yes. The $3 million added to that, occurring on the next page, is for the deep space net for construction in Australia and South Africa.

Mr. THOMAS. You have $5,850,000 for construction, including the MERCURY net?

Dr. SILVERSTEIN. Yes.

Mr. THOMAS. Is this all new construction? Has it already been started or will it be funded out of the 1961 money?

Dr. SILVERSTEIN. The MERCURY network has been started. These funds essentially are to complete the construction at many sites. The other money is for starting. The $3.450 million is new construction; the $2.4 for the MERCURY nets will be a continuation of work underway.

Mr. THOMAS. What is the size of the building?

Dr. SILVERSTEIN. There are several buildings. One building houses technical equipment. There are outbuildings for some of the auxiliary equipment. There are fuel storage cribs, pumping stations and other minor buildings.

Mr. THOMAS. That is roughly $6 million. How do you account for your other $21,750,000?

Dr. SILVERSTEIN. It is largely new equipment that is being added in these nets to increase their capability. In the minitrack net, for example, we are providing for such items as automatic readout of the data. We will have a number of satellites in space at once, and it will be necessary to get data from them in a continuing process. We are providing equipment to change frequencies as required.

Mr. THOMAS. You have $5 million for several types of equipment under your deep space.

For your minitracks, what do you have?

Dr. SILVERSTEIN. For minitrack, we have a total of $4,750,000 from which I subtract the $450,000 previously mentioned for construction, and I will get $4,300,000 for equipment.

Mr. THOMAS. What about your MERCURY net?

Dr. SILVERSTEIN. In the MERCURY net, we are, as you know, putting in 18 stations with the various equipment that is required. The particular items are listed here, the various systems we are spending money on in 1961.

In particular, we have to modify some of the S-band radar equipment with new parts, to modify and bring them up to date for longer range detection.

Mr. THOMAS. There is $15 million for MERCURY. Is this all new acquisition of equipment?

Dr. SILVERSTEIN. New acquisition and modification of some existing S-band equipment we now have.

Mr. ULMER. Except for the $2.4 million for construction; so it is $13.6. We are requesting for equipment or for equipment modernization.

Mr. THOMAS. How firm is this figure of $15 million? You have covered about 15 or 20 items. Can you come within 20 percent of it and, if so, how do you arrive at your estimate?

Dr. SILVERSTEIN. We, of course, are working with Western Electric in this contract and have estimates from them for these various pieces of equipment. How firm they are, I cannot say.

Mr. THOMAS. Who is your general contractor? Were you able to give us an answer to that question? How firm this figure of $15 million is?

Dr. SILVERSTEIN. I think it could be classed as a good engineering estimate.

Mr. THOMAS. Who is your prime contractor here?

Dr. SILVERSTEIN. Western Electric Co. on the MERCURY net.

Mr. THOMAS. Do they bid on this? Do you turn them loose with a cost-plus contract?

Dr. SILVERSTEIN. A negotiated contract.

Mr. THOMAS. Does he manufacture the equipment for you?

Dr. SILVERSTEIN. Part of the equipment he manufactures, part he subcontracts for.

Mr. THOMAS. That is Western Electric?

Dr. SILVERSTEIN. Yes, sir.

Mr. OSTERTAG. It is part competitive and part negotiations?

Dr. SILVERSTEIN. The contractor was selected by negotiation among a number of people who offered proposals.

Mr. THOMAS. Does Western Electric do the manufacturing, go to the field, and also do your construction?

Dr. SILVERSTEIN. They are the general contractors.

Mr. THOMAS. I thought they were the manufacturing unit for the A.A. & T. I did not know they went to the field and built.

Dr. SILVERSTEIN. They have had experience in this type of work before, in managing large installations of radar equipment.

Mr. JONAS. If the chairman will yield, they had the prime contract for the NIKE. They have been in this ever since we have been working on that, is that right?

Mr. THOMAS. Also for the DEW line. Here is an item that needs a little explanation: Test and checkout of station equipment, $3 million; special test equipment, $2,200,000. That is $5,200,000. What do those two items mean?

Dr. SILVERSTEIN. When you install a station, you have to make sure that the station is operating properly and one process you use is to

send airplanes aloft with the right beacon equipment in them, fly over the station and zero in the station on the equipment in the airplane.

Mr. THOMAS. How do you arrive at that figure of $3 million? I went on a plane. We checked out 27 in 1 day not long ago.

Dr. DRYDEN. This is comparable to the FAA flights to check out their beacon systems.

Mr. THOMAS. How do you get $3 million out of it?

Dr. DRYDEN. There are 18 sites all over the world at which this calibration has to be made.

Mr. THOMAS. Who does it for you?

Dr. SILVERSTEIN. It will be contracted.

Mr. THOMAS. Who is your contractor?

Dr. SILVERSTEIN. We have not as yet contracted for many of these checkouts. The stations are not completed. We are in the process of preparing the specifications.

Mr. THOMAS. This figure of $3 million is pretty much of a guess figure?

Dr. DRYDEN. It is based on the cost of chartering aircraft. Many countries require that we use only civil aircraft in this work.

Mr. THOMAS. Can the FAA not do this? They are the best experts we have on it in this country.

Dr. DRYDEN. They would have to turn over an airplane and install a lot of equipment for this purpose.

Mr. THOMAS. They have the equipment and the planes.

Dr. DRYDEN. They do not have the equipment to check this type of station.

Dr. SILVERSTEIN. This is special equipment to check the particular ground equipment we have. There is quite a bit of ground equipment. You have not only to check the radars, of which there are two types on the various stations, but also the various stations at their various frequencies.

Mr. THOMAS. Does it require special equipment?

Dr. SILVERSTEIN. In the airplanes; yes.

Mr. THOMAS. How do you arrive at your contract with your prime contractor on this equipment? Is this a straight negotiated bid?

Dr. SILVERSTEIN. We started off by calling a meeting and describing the specifications to a group of some 24 different contractors.

Mr. THOMAS. How many people in this country are engaged in making this type equipment? General Electric and Western Electric?

Dr. DRYDEN. Reeves Instrument Co.

Dr. SILVERSTEIN. Collins. Many people can make it.

Mr. THOMAS. There is a lot of competition?

Dr. SILVERSTEIN. There was good competition.

Mr. THOMAS. What kind of contract did you finally let? Did you sit down and say, "I want so many of X items. Sharpen your pencil. We want a competitive bid out of you gentlemen," or did you turn it over to them with a negotiated contract and kiss it off?

Dr. SILVERSTEIN. There are some items in the proposals that could be handled in that way, but at the time that we entered into this negotiated contract, because of the leadtime required to establish these stations and because of the need to match the MERCURY schedule with the tracking net, we were not able at that time even to get into many of these countries to find out exactly what sites would be available. During that period, in order to move as rapidly as possible in this program, we have proceeded with contract negotiations while undertaking through the Department of State negotiations with various countries to arrange agreements for the locations of these stations within these countries.

This has been a continuing process through the whole period of building up of the equipment. It had to be done simultaneously.

Mr. THOMAS. How many of these Minitrack stations are there, 11 or 14?

Dr. SILVERSTEIN. Fourteen.

Mr. THOMAS. You are operating those 14.

Dr. DRYDEN. Twelve optical.

Mr. THOMAS. That makes 26?

Dr. DRYDEN. Three deep space.

Mr. THOMAS. Is that 24 or 14 Minitrack?

Dr. DRYDEN. Fourteen Minitrack, twelve optical stations.

Mr. THOMAS. Three deep space?

Dr. DRYDEN. That is right.

Mr. THOMAS. What is that, 16 in the MERCURY?

Dr. DRYDEN. The 16 includes some existing military stations.

Dr. SILVERSTEIN. There are 16 stations in the net.

Mr. THOMAS. I believe you said in there three of them were operated by somebody else.

Is that going to be a reimbursable cost for the 16?

Dr. SILVERSTEIN. The reimbursable costs where the military operate are only those extra costs associated with a particular operation.

Mr. THOMAS. You have 45 stations. What does it cost you to operate them in 1961?

Dr. SILVERSTEIN. The total cost will be around $50 million.

Mr. THOMAS. $32 million of it is charged over in R. & D. Is any of it charged against construction?

Dr. SILVERSTEIN. Not for operation. Of the $32 million in R. & D., some $25 million of that is for operation; $7 million is for the development of new equipment; there is another $25 million for the operation of the MERCURY net.

Mr. THOMAS. Where is that $25 million charged to?

You have it under R. & D., about $7 million for new gadgets and $25 million for operations. You have here an additional $27,750,000. A big part of it is for new equipment.

What part of this $27.5 million is for operation and where is the rest of the money being funded from?

Dr. SILVERSTEIN. None of this $27.5 million is for operation. However, in the R. & D. budget you will find an item under the manned space flight program for operation of the MERCURY net and you will find another item in the tracking and data acquisition program for some $25 million for operation of the other stations.

Mr. THOMAS. Pull it all together where we can get at it in one spot. In addition to this $27.5 million, mainly for construction, you have another $25 million for operations charged under research projects.

Dr. SILVERSTEIN. That is right.

Mr. THOMAS. Then in addition to that you have another $32 million charged under another program, where $25 million is for operation and $7 million is for new equipment.

Dr. SILVERSTEIN. I can point out in the book where these items can be found.

Dr. DRYDEN. Pages 167 and 201 in the second book are the items on operations.

Dr. SILVERSTEIN. On page 167 there is a sum of $24,670,000 for the MERCURY tracking network operations and minor equipment in this area and on pages 201 and 202 the cost of operating the rest of the tracking networks are shown; they add up to some $25,300,000.

Mr. THOMAS. You set out your big sum back here of $32 million under a separate head. You charge some to MERCURY. What is the other project you charge it to? I wish at this point in the record you will pull this together where we can see this.

Dr. DRYDEN. MERCURY is a temporary network useful for the single project. Most of the equipment is movable and will be moved when that project is over, so that cost is shown under the manual space flight program. The operating costs for all other tracking stations which are useful permanently in the program are grouped under the tracking and data acquisition program.

Mr. THOMAS. You have 16 MERCURY stations. What will it cost you to operate them on an annual basis? How many people will there be at each?

Dr. SILVERSTEIN. These stations will be operated under contract, The estimate right now is that there will be a total of about 550 contract personnel at all of these sites.

Mr. THOMAS. At the 16?

Dr. SILVERSTEIN. At 16 different sites—actually, at 18 sites.

We have 16 tracking stations——

Mr. THOMAS. This is not the Smithsonian group, is it?

Dr. SILVERSTEIN. No, sir. As yet we have not contracted for the operation of all of these MERCURY net stations.

Mr. THOMAS. How do you arrive at the $25 million? How do you know what it will cost? How are you going to let your contract? What is your yardstick?

Dr. SILVERSTEIN. We have experience in the operation, for example, of the minitrack net where we have a contractor now. We know the approximate number of people it takes to operate these stations.

Mr. THOMAS. Who is your contractor there?

Dr. SILVERSTEIN. Bendix Aviation.

Mr. THOMAS. What does that cost you for your 14?

Dr. SILVERSTEIN. The cost is approximately $3 million in 1960.

Dr. DRYDEN. $4,750,000 in 1961, plus $850,000 for data transmission, and plus some funds for maintenance and repairs. That is on page 201.

Mr. THOMAS. Mr. Ulmer, will you pull these costs together for your minitrack, deep space, and MERCURY for 1959, 1960, and 1961; first, on your construction cost; second, on your parts cost; third, on your salaries and expenses cost, regardless of whether you charge it here under this budget or the other budget, under R. & D. or operations, but I want to see what your operation cost is.

Mr. ULMER. Fine.

Mr. THOMAS. Include your construction cost.

Your construction cost ought to have two columns, one for your equipment and one for construction.

Mr. ULMER. I will be very glad to, Mr. Thomas.

(The information is as follows:)

National Aeronautics and Space Administration

Funding for tracking networks

Network	Research and development			Construction and equipment			Total		
	1959	1960	1961	1959	1960	1961	1959	1960	1961
Satellite (Minitrack) stations:									
Construction				$95,000	$1,561,000	$450,000	$95,000	$1,561,000	$450,000
Equipment					2,644,000	4,300,000		2,644,000	4,300,000
Operations	$1,250,000	$3,150,000	$5,150,000				1,250,000	3,150,000	5,150,000
Advanced development		1,390,000	4,670,000					1,390,000	4,670,000
Data transmission and reduction	200,000	1,300,000	1,050,000				200,000	1,300,000	1,050,000
Total	1,450,000	5,840,000	10,870,000	95,000	4,205,000	4,750,000	1,545,000	10,045,000	15,620,000
Optical stations:									
Operations	200,000	1,700,000	2,300,000				200,000	1,700,000	2,300,000
Data transmission and reduction	410,000	800,000	1,300,000				410,000	800,000	1,300,000
Total	610,000	2,500,000	3,600,000				610,000	2,500,000	3,600,000
Deep space stations:									
Construction						3,000,000			3,000,000
Equipment		1,275,000	1,050,000	2,550,000	3,500,000	5,000,000	2,550,000	4,775,000	6,050,000
Operations		1,500,000	3,330,000					1,500,000	3,330,000
Advanced development	348,000	175,000	1,000,000				348,000	175,000	1,000,000
Data transmission and reduction		350,000	500,000					350,000	500,000
Total	348,000	3,300,000	5,880,000	2,550,000	3,500,000	8,000,000	2,898,000	6,800,000	13,880,000
Mercury stations:									
Construction					9,535,000	2,400,000		9,535,000	2,400,000
Equipment		90,000	20,000	2,425,000	26,260,000	12,600,000	2,425,000	26,350,000	12,620,000
Operations	7,000	5,620,000	26,550,000				7,000	5,620,000	26,550,000
Advanced development	507,674	500,000	500,000				507,674	500,000	500,000
Data transmission and reduction		2,200,000	6,150,000					2,200,000	6,150,000
Total	514,674	8,410,000	33,220,000	2,425,000	135,795,000	15,000,000	2,939,674	44,205,000	48,220,000
Non-NASA stations:									
Operations	180,000	900,000	1,400,000				180,000	900,000	1,400,000
Data transmission and reduction		100,000	150,000					100,000	150,000
Total	180,000	1,000,000	1,550,000				180,000	1,000,000	1,550,000

AMR and PMR stations: Operations		626,000	2,100,000					626,000	2,100,000
All stations:									
Construction				95,000	11,096,000	5,850,000	95,000	11,096,000	5,850,000
Equipment		1,365,000	1,070,000	4,975,000	32,404,000	21,900,000	4,975,000	33,769,000	22,970,000
Operations	1,637,000	13,496,000	40,830,000				1,637,000	13,496,000	40,830,000
Advanced development	855,674	2,065,000	6,170,000				855,674	2,065,000	6,170,000
Data transmission and reduction	610,000	4,750,000	9,150,000				610,000	4,750,000	9,150,000
Total, all stations	3,102,674	21,676,000	57,220,000	5,070,000	43,500,000	27,750,000	8,172,674	65,176,000	84,970,000

[1] Includes pending fiscal year 1960 supplemental in the amount of $6,800,000.

Mr. THOMAS. What is the yardstick you use in your minitrack stations?

Did you say that figure was $4,500,000 operating cost a year?

Dr. SILVERSTEIN. $4,750,000 for operation of the microlock and minitrack stations; the figure includes $850,000 for data transmission.

Mr. THOMAS. What is your yardstick? How did you pick these people? Why did you pick them over and above X, Y, or Z? What did they have to offer, in other words?

Dr. SILVERSTEIN. These people initially were the contractors when the stations were first established, when they were a part of the VANGUARD program.

They have built up a staff at these stations, many of which are abroad, that lives at the sites and is qualified to operate the stations.

They are intimately familiar with the operations. We have continued to contract with them.

Dr. DRYDEN. At some of the stations, as I explained, we have been able to negotiate arrangements with foreign countries by which they carry the complete operating costs.

Mr. THOMAS. You have set it out here scattered over 30 pages in your justifications.

Name your contractors and the stations they operate. Let us have one table and what you pay him.

(The information follows:)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Tracking network operating costs

Network	Contractor or operator	1959	1960	1961
Satellite (Minitrack) stations:				
Blossom Point, Md.				
San Diego, Calif.				
Fort Myer, Fla.				
Quito, Ecuador [1]	Bendix	$1,250,000	$2,450,000	$3,850,000
Lima, Peru [1]				
Antofagasta, Chile [1]				
Santiago, Chile [1]				
East Grand Forks, Minn.[2]				
Fairbanks, Alaska [2]	University of Alaska			
Antiqua, British West Indies	Radio Corp. of America			
St. Johns, Newfoundland [2]	Canada		675,000	1,000,000
Woomera, Australia	Australia			
Esselen Park, South Africa	South Africa			
South England [2]	England			
Operation of 3 Microlock stations.	Not selected		25,000	300,000
Total		1,250,000	3,150,000	5,150,000
Optical stations:				
Hobo Sound, Fla.				
White Sands, N. Mex.				
Haleakala, Hawaii				
Curacao, North West Indies				
Arequipa, Peru	Smithsonian Astrophysical Observatory.	150,000	1,450,000	2,050,000
Villa Dolores, Argentina				
Olifantsfontein, South Africa				
Cadiz, Spain				
Shiraz, Iran				
Woomera, Australia	Smithsonian Astrophysical Observatory, Australia, Department of Supply.			
Mitaka, Japan	Smithsonian Astrophysical Observatory, Japan.			
Naini-Tal, India	Smithsonian Astrophysical Observatory, India.			
Moon Watch (130 active stations).	Volunteer teams	50,000	250,000	250,000
Total		200,000	1,700,000	2,300,000

See footnotes at end of table.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION—Continued

Tracking network operating costs—Continued

Network	Contractor or operator	1959	1960	1961
Deep space stations:				
Goldstone, Calif.	Jet Propulsion Laboratory		$1,200,000	$1,280,000
Woomera, Australia	Australia, Department of Supply		300,000	950,000
South Africa	Union of South Africa			700,000
Trajectory equipment operation.	Not selected			400,000
Total			1,500,000	3,330,000
Mercury stations:				
Cape Canaveral (Air Force Missile Test Center.	Department of Defense, Atlantic Missile Range with NASA manager.			
Mid-Atlantic Ship	Department of Defense, Atlantic Missile Range.			
Indian Ocean Ship	do			
Canton Island	Department of Defense, Pacific Missile Range.			
Kauai, Hawaii	do			
Point Mugu, Pacific Missile Range.	do			
White Sands, New Mexico	Department of Defense, White Sands Missile Range.	$7,000	5,620,000	26,550,000
South Texas	do			
Eglin Air Force Base, Florida.	Department of Defense, Eglin Air Force Base.			
Bermuda	Not selected			
Canary Islands	do			
Kano, Nigeria	do			
Zanzibar, Africa	do			
Woomera, Australia	Australia, Department of Supply			
West Australia (Perth)	do			
West Mexico	Not selected			
Total		7,000	5,620,000	26,550,000
Non-NASA stations:				
Jodrell Bank, Manchester, England.	University of Manchester	180,000	200,000	300,000
Fort Churchill, Canada	Canada (via—Army cognizance)		650,000	700,000
Phototrack stations	Society of Professional Photographic Engineers.			
Japan station for telemetry	Japan			
University of Heidleberg	University of Heidleberg			
Kaena Point, Hawaii	Air Force Ballistic Missile Division			
Deal, N.J.	Army Signal Corps		50,000	400,000
Special tracking services for ABLE IV.	Space Technology Laboratories, Air Force Ballistic Missile Division.			
Special telemetry services for Explorer VII.	Department of Commerce, Weather Bureau.			
Total		180,000	900,000	1,400,000
Atlantic Missile Range and Pacific Missile Range stations:				
Atlantic Missile Range operations.	Department of Defense, Atlantic Missile Range.		426,000	1,500,000
Pacific Missile Range operations.	Department of Defense, Pacific Missile Range.		200,000	600,000
Total			626,000	2,100,000
All stations		1,637,000	13,496,000	40,830,000

[1] These stations are partially staffed and operated by indigenous personnel, depending on the availability of technically qualified personnel. Through a training program by Bendix this capability is being extended, so as to permit fullest possible use of indigenous personnel.

[2] These stations are not yet in operation, but are expected to become operational by the end of 1960.

Mr. THOMAS. You pay him $4½ million. Your next group is Smithsonian. They have 12. What do you pay them? How did you arrive at the contracts?

Smithsonian is not in the business of operation. It has two or three stations, one or two in Central America and one or two in California.

I did not know they were in the global business.

Dr. DRYDEN. It is the Smithsonian Astrophysical Observatory at Harvard that actually operates our optical tracking stations for us.

Mr. THOMAS. Most of these are outside of the continental United States, though.

Dr. DRYDEN. That is true.

Mr. THOMAS. What do you pay them, and what yardstick do you use?

Mr. ULMER. $1,950,000 is in 1961 budget for that purpose. An additional $100,000 will be required for maintenance and repairs.

Mr. THOMAS. How do you arrive at that figure? What is the basis of it?

Dr. DRYDEN. It is based on the number of people that are required, their travel costs, supplies, equipment, etc.

Mr. THOMAS. Is this on purely a reimbursable basis, and do you let Smithsonian make a little money?

Dr. DRYDEN. Smithsonian does not make any money.

Mr. ULMER. It is on an actual cost grant basis, Mr. Thomas.

Mr. THOMAS. What is your next group of contractors? You have seven stations in the United States. Who is your contractor for them, and what are you paying for those?

Dr. SILVERSTEIN. Five of these stations are minitrack stations and will be included in the first category.

Now, in the MERCURY net we have a number of stations in this country, most of which are under military jurisdiction currently and will be operated by the military station people.

The only costs that will be reimbursable for those stations will be the extra costs associated with their operation in connection with the MERCURY program.

Mr. THOMAS. You have 16 MERCURY stations.

How many are located in the continental United States? There are no more than four at the most.

Dr. SILVERSTEIN. There actually will be 7 of the 18 points in this country.

That includes Mugu, White Sands, a station in Texas, Eglin, Canaveral, Goddard.

I missed one. Hawaii is the other one.

Mr. THOMAS. I cannot see how you arrive at a firm figure of $27,750,000 on this. It appears to me you could miss it 15 or 20 percent either way, mostly over.

Dr. DRYDEN. From our past experience we can estimate construction costs on the average within a very few percent. With the individual case some of them may run 5 to 10 percent over, some of them 5 to 10 percent less, but on the average, the number of these cases, our past experience shows we can come within a few percent.

Mr. THOMAS. If we gave you $25 million for this item, can you do your job and have an unexpended balance of about $1 million left?

Dr. DRYDEN. This might come out that way. I would not like to promise you.

Mr. THOMAS. We will trade with you.

Research and Development

Program and financing

	1959 actual	1960 estimate	1961 estimate
Program by activities:			
1. Aeronautical and space research:			
(a) Support of NASA plant	$2,271,100	$11,500,000	$22,000,000
(b) Research grants and contracts	256,950	2,000,000	6,000,000
2. Space flight development and operations:			
(a) Support of NASA plant	613,000	4,000,000	23,000,000
(b) Scientific investigations in space	16,808,332	45,000,000	85,000,000
(c) Satellite applications	233,282	5,000,000	15,000,000
(d) Manned space flight	4,339,192	50,000,000	80,000,000
(e) Vehicle development	21,404,778	90,182,980	98,000,000
(f) Space propulsion technology	5,261,086	25,000,000	52,000,000
(g) Vehicle systems technology	2,972,610	5,000,000	12,000,000
(h) Tracking and data acquisition	911,334	11,000,000	15,000,000
3. Program direction: Support of NASA plant	44,716	1,500,000	2,000,000
Total program costs	55,116,380	250,182,980	410,000,000
4. Supplies or services transferred in (−) without charge, net	−2,408,121	−1,560,931	−1,637,000
Total program costs, funded	52,708,259	248,622,049	408,363,000
5. Relation of costs to obligations: Obligations incurred for costs of other years, net	142,300,252	132,946,972	213,090,000
Total program (obligations)	195,008,511	381,569,021	621,453,000
Financing:			
Comparative transfers from (−) Department of Defense	−19,325,020	−55,182,980	
Unobligated balance transferred from "U.S. scientific satellite," Department of Defense (72 Stat. 433)	−25,541,282		
Unobligated balance brought forward		−20,936,041	−20,000,000
Advances and reimbursements from other accounts (−)		−5,100,000	−5,000,000
Unobligated balance carried forward	20,936,041	20,000,000	25,000,000
New obligational authority	171,078,250	320,350,000	621,453,000
New obligational authority:			
Appropriation	50,000,000	335,350,000	621,453,000
Transferred (72 Stat. 433) from—			
"Salaries and expenses, Advanced Research Projects Agency, Department of Defense"	59,200,000		
"Aircraft, missiles, and related procurement, Air Force"	45,100,000		
"Research, development, test, and evaluation, Air Force"	12,700,000		
"Research, development, test, and evaluation, Army"	4,078,250		
Transferred to "Construction and equipment, National Aeronautics and Space Administration" (Public Law 86-213)		−15,000,000	
Appropriation (adjusted)	171,078,250	320,350,000	621,453,000

Object classification

	1959 actual	1960 estimate	1961 estimate
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION			
Total number of permanent positions	356		
Average number of all employees	150		
Number of employees at end of year	356		
Average GS grade and salary	11.3 $7,295		
Average salary for grades established by the Administrator of the NASA	$4,312		
01 Personal services:			
Permanent positions	$1,016,436		
Positions other than permanent	1,687		
Other personal services	153,870		
Total personal services	1,171,993		
02 Travel	188,693		
03 Transportation of things	9,182	$1,485,000	$3,993,000
04 Communication services		2,346,500	7,786,000
07 Other contractual services:			
Repairs and alterations	129,878	2,022,022	5,060,000
Miscellaneous services	54,995,270	154,487,332	338,614,000
Services performed by other agencies	91,138,549	145,182,980	140,000,000
08 Supplies and materials	42,440,520	60,000,000	100,000,000
09 Equipment	2,863,401	16,000,000	26,000,000
11 Grants, subsidies, and contributions	65,914		
15 Taxes and assessments	298		
Total, National Aeronautics and Space Administration	193,003,698	381,523,834	621,453,000
ALLOCATION ACCOUNTS			
Total number of permanent positions	3		
Average number of all employees	2		
Average GS grade and salary	6.0 $5,242		
01 Personal services:			
Permanent positions	$10,389		
Other personal services	149		
Total personal services	10,538		
04 Communication services	59		
07 Other contractual services	1,880,479	30,483	
09 Equipment	1,789	239	
10 Lands and structures	111,270	14,465	
11 Grants, subsidies, and contributions	678		
Total, allocation accounts	2,004,813	45,187	
Total obligations	195,008,511	381,569,021	621,453,000
Obligations are distributed as follows:			
National Aeronautics and Space Administration	193,003,698	381,523,834	621,453,000
Department of the Army	132,836	17,164	
Atomic Energy Commission	1,871,977	28,023	

Mr. THOMAS. Gentlemen, let us take a look at our "Research and development" docket; $621,453,000 is requested.

This is against $335,350,000 last year.

This appropriation provides for the contractual cost of research and development, procurement and operations. Those words mean just exactly what they say, for contractual costs.

By that, there are no NASA salaries or S. & E. type expenses in this appropriation.

Dr. DRYDEN. That is correct. There are no salaries for NASA employees here.

Mr. THOMAS. None of those are charged against this appropriation. As a matter of fact, there is a prohibition in the language against this.

Dr. DRYDEN. That is right.

Mr. THOMAS. This is rather broad in scope. It covers the aeronautical and space research, and of course you have a tremendous item here in support of your plants.

They are becoming quite numerous, are they not?

Dr. DRYDEN. This item covers the expenses related to the inhouse work which are performed by contractual arrangements, the purchase of supplies, materials, equipment, and so forth.

RESEARCH GRANTS AND CONTRACTS

Mr. THOMAS. Let us look at your research grants and contracts.

How many have you obligated to January 1 of your 1960 funds for research contracts? Give us a list of the institutions with whom you have the contracts and the dollar amount involved in each one.

Mr. ULMER. The list would not show in the book that you have.

Mr. THOMAS. That is not a secret is it?

Mr. ULMER. Not at all, sir. In fact, I have a listing here that I should have put in the book. I will give it to you.

Mr. THOMAS. Put it in the book next year unless you want to keep it a secret.

Mr. ULMER. This is a complete list of all obligations made against the 1959 funds——

Mr. JONAS. If the chairman will yield, what we want to know is a list of the 10 million, not last year.

Mr. THOMAS. I think that is what this is.

Mr. ULMER. That is a list of the contracts that have been let to date out of the 1959 and 1960 money.

UNOBLIGATED BALANCES

Mr. THOMAS. Tell us what your unobligated balance is, as of January 1.

Mr. ULMER. My figures are as of the close of business on January 31. Out of the $4.9 million available in 1960 we had under contract $1.1 million, and an additional amount of $900,000 awaiting final contractual obligation; so approximately $2 million of the $4.95 million is obligated or committed.

Mr. THOMAS. We suggest you not obligate any more of that money until we can take a look at it for this year. We will talk to you later about it.

The National Science Foundation is in the same business you are in. They have every conceivable type of contract, anywhere from $100 million to $128 million.

Dr. DRYDEN. Every agency in the technological business finds it extremely economical to use the services of experts at universities for certain jobs.

Mr. THOMAS. You have your own experts; you have these other people.

Dr. DRYDEN. We cannot dictate to the Science Foundation that they should make a contract to support a particular job of ours.

Mr. THOMAS. They would be glad to do it. They are looking for business.

Mr. JONAS. Maybe we can help you a little.

Dr. DRYDEN. We have a full exchange of information. They are supporting research at universities of a very broad nature.

We are supporting research directly related to the jobs that we are doing.

Mr. YATES. Mr. Chairman, will you yield for a question?

Mr. THOMAS. Yes.

Mr. YATES. How does one know how much money is allocated under each of those contracts?

Mr. ULMER. It is shown on the form, Mr. Yates. The figures are shown in thousands. The .38 figure would be $380,000.

MEDICAL RESEARCH

Mr. THOMAS. What is the basis of your new program?

I gained from reading the justification you are going into the field of medicine.

Dr. DRYDEN. We are in the space business, in the business of putting man in space. If we are going to put man in space, we have to get through the military services and through the university research program, the necessary information about these biomedical problems.

Mr. BOLAND. Is the Department of Defense doing precisely the same thing with respect to the sciences that you are doing?

Dr. DRYDEN. The Department of Defense is engaged in bioengineering. They have investigated what stress a man can take, how much acceleration. We are concerned with going far out into space and the problems associated with man's existing in space over a long period of time, the biological effects of space on the basic characteristics of organisms and life generally. We will use the laboratories of the military services and reimburse them for work in connection with our program.

Right now, we are the largest single user of the Navy's Johnstown facility in Pennsylvania. We give them more work in connection with the X–15 program and MERCURY program than the Navy themselves are doing there.

All of our biomedical experiments in which monkeys were used were carried out with the service laboratories—the School of Aviation Medicine in Texas; I think in one case the Bethesda Naval Medical Center—so we are using the facilities of the services.

The services have assigned medical officers to work on Project MERCURY.

They are located at Langley Field; with the astronauts, with the project.

Mr. BOLAND. The explanation sounds good. Who was the admiral who appeared before the legislative committee?

Dr. DRYDEN. Hayward.

Mr. BOLAND. I understand he said they were doing precisely what you did and NASA has no necessity to get into this.

Dr. DRYDEN. NASA is not doing a thing now.

Mr. BOLAND. You want money to do it.

Dr. DRYDEN. I said we are going into the area of bioscience. In the bioengineering aspects, such as pressure suit design, G–suit design, life support equipment, we are and will continue to use the service laboratories but this is a far cry from a man going out to the moon for several days and back.

Mr. THOMAS. Can you give us a breakdown of your contemplated expenditure of $10 million next year for your research?

Dr. DRYDEN. We can give it by general fields. We can give you some of the projects under consideration. The agencies involved in contracting with universities have established a full exchange of information on programs. On the biosciences we did not go off and make a decision of this kind on our own. We appointed a committee, headed by Dr. Kety of the NIH and including other distinguished physicians who are concerned with these problems, to study what NASA should do. The steps that we are about to take are based on the recommendations of that committee.

If you heard Mr. Douglas' testimony before the other committee, he explained how Dr. Glennan and I and others went to the Department of Defense and discussed exactly this problem and they are completely satisfied that we are coordinating the plans with the Defense Department.

FUTURE CONTRACTS

Mr. THOMAS. What we are interested in is how do you arrive at that figure of $10 million and we would like to see a breakdown of it, by institutions and some description.

Can you furnish that now?

Mr. ULMER. We do not have that with us, Mr. Thomas.

Mr. THOMAS. How do you arrive at that figure of $10 million?

Dr. DRYDEN. The $10 million is based on judgment—we obviously cannot tell you what university we are going to make a contract with 6 months from now. This depends on getting proposals in certain technical areas from a number of universities, evaluating the proposals, discarding some of them, and accepting some of them.

The breakdown we can give you is the amount of money that we expect to spend in certain fields.

Mr. THOMAS. I thought you made this budget 6 months in advance.

Dr. DRYDEN. This is why I say we cannot give you a list of future contracts. We can tell you what we spent the money for last year, what the approximate distribution will be in the coming year. This is shown on page 146, by field—physical sciences, cosmological sciences, bio-sciences.

Mr. THOMAS. That does not mean much.

Mr. JONAS. Will you yield, Mr. Chairman?

Mr. THOMAS. Yes.

Mr. JONAS. What you mean, Dr. Dryden, is that you selected the financing of $10 million before you even got the projects under study; is that right?

Dr. DRYDEN. This is not based on projects that we have in hand. That is correct. This is a level that we think we will——

Mr. JONAS. The proportion of your money you think you should spend for university research?

Dr. DRYDEN. It is not a fixed ratio.

Mr. JONAS. It has a relationship?

Dr. DRYDEN. Yes.

Mr. JONAS. Really it is a dollar figure instead of based on planned project?

Dr. DRYDEN. Yes. I think this is true in the Science Foundation also.

Mr. JONAS. I think that is right.

Dr. DRYDEN. Or in the Office of Naval Research which has exactly the same problem.

JUSTIFICATION OF PROGRAMS

Mr. THOMAS. Mr. Reporter, put pages 103, 104, and 105 in the record.

This breaks down your programs.

(The pages referred to follow:)

PROGRAM AND PERFORMANCE

This appropriation provides for the contractual costs of research, development, procurement, and operations.

1. *Aeronautical and space research.*—(*a*) Support of NASA plant: The increase in 1961 in the requirements for contractual services, supplies, and equipment required in the operation of the NASA research centers results chiefly from the need for providing the laboratories with new specialized types of equipment required for research on problems of space which were not required in prior years when the principal emphasis was on aeronautics.

(*b*) Research grants and contracts: The 1961 program contemplates additional support of research on materials and in certain fields, such as the space aspects of medical and biological research, for which the NASA does not have a capability at its own research centers.

2. *Space flight development and operations.*—(*a*) Support of NASA plant: Funds are provided in this subactivity for contractual services, supplies, and equipment required in the operation of the NASA space flight development centers, stations, and offices. The increase in 1961 is required to support the increased personnel and workload of these organizations.

(*b*) Scientific investigations in space: This provides for an increased scientific program in space in 1961, utilizing sounding rockets, earth satellites, and lunar and planetary probes.

(*c*) Satellite applications: Development of meteorological and passive communications satellites will be continued in 1961.

(*d*) Manned space flight: The funding included for 1961 is expected to carry the MERCURY program into the operational phase. In addition, a supplemental appropriation is anticipated for 1960 and is shown below under "Proposed for later transmission."

(*e*) Vehicle development: This subactivity provides for the development, fabrication, and launching of advanced space vehicles. Principal emphasis in 1961 will be on the SATURN very high thrust booster vehicle and on the CENTAUR vehicle with a high-energy upper stage.

(*f*) Space propulsion technology: This subactivity funds the development of advanced propulsion techniques and systems for application to future space vehicles. Work will be continued in 1961 on the single chambered 1.5-million-pound thrust engine; advanced liquid and solid fuel rocket engines; nuclear rocket and electrical propulsion systems; and nuclear, solar, and electrical auxiliary power supplies for payload applications.

(*g*) Vehicle systems technology: Increased funding is provided in 1961 for developing systems and components for midcourse and terminal guidance, and attitude control systems for payload packages.

(*h*) Tracking and data acquisition: This subactivity provides for the operation by contract of the minitrack satellite tracking network, the deep space network, and the special tracking facilities for the MERCURY manned space flight program. It also covers costs of data transmission and reduction, and research and development in the fields of tracking, data acquisition, and data handling.

3. *Program direction.*—This activity provides for the contractual services, supplies, and equipment for the administration's headquarters and western operations offices.

4. *Relation of costs to obligations.*—The relationship is derived from yearend balances of selected and applicable adjustment resources as reflected in the following table:

	1958 actual	1959 actual	1960 estimate	1961 estimate
Selected resources at end of year:				
Inventories and items on order:				
Stores (goods unconsumed by projects)	$2,514,811	$2,375,654	$2,360,642	$3,080,642
Unpaid undelivered orders (appropriation balances obligated for goods and services on order not yet received)		140,821,634	273,299,471	484,669,471
Advances (payments for goods and services on order not yet received)		1,515,853	2,000,000	3,000,000
Total selected resources at end of year	2,514,811	144,713,141	277,660,113	490,750,113
Selected resources at start of year (−)		−2,514,811	−144,713,141	−277,660,113
Adjustment of selected resources reported at start of year		101,922		
Obligations incurred for costs of other years, net		142,300,252	132,946,972	213,090,000

Summary of Estimates, 1961

Mr. Thomas. Put the summary sheet on page 109 in the record. (The page referred to follows:)

Research and development programs

Program	Fiscal year 1959	Fiscal year 1960	Fiscal year 1960 supplemental	Fiscal year 1961
Aeronautical and space research:				
Support of NASA plant	$1,097,651	$22,684,000		$51,345,000
Research grants and contracts	3,028,000	4,950,000		10,000,000
Support of JPL plant	[1] 8,156,500			
Scientific investigations in space:				
Sounding rockets	3,556,170	8,811,000		8,000,000
Scientific satellites	21,305,114	23,813,000		41,700,000
Lunar and planetary exploration	31,882,607	49,000,000		45,000,000
Vanguard	[1] 21,943,582			
Satellite applications:				
Meteorology	987,550	7,930,000		20,700,000
Communications	3,574,806	3,170,000		5,600,000
Manned space flight	46,416,333	74,962,000	$12,200,000	107,750,000
Vehicles systems technology	1,903,651	6,737,000		21,200,000
Space propulsion technology:				
Solid rockets	615,898	3,785,000		2,800,000
Liquid rockets	15,978,589	30,328,000		63,000,000
Nuclear systems technology	3,810,476	6,000,000		10,000,000
Space power technology		4,814,000		8,000,000
Vehicle development:				
SCOUT	6,048,000	2,800,000		
DELTA	12,927,417	13,300,000		12,500,000
VEGA	14,291,494	4,000,000		
CENTAUR	4,000,000	37,000,000		47,000,000
SATURN				134,308,000
Tracking and data acquisition	3,095,674	16,266,000		32,550,000
Total	204,619,532	320,350,000	12,200,000	621,453,000

[1] Funded under program activities in 1960 and 1961.

Mr. Thomas. Your breakdown shows for support of your plants, $51,345,000 next year. The research grants we have just discussed. Your next heading is "Scientific investigations in space."

Sounding rockets are $8 million; satellites, $41.7 million; lunar and planetary exploration, $45 million.

Satellite applications: Meterology, $20.7 million; communications, $5.6 million. Then manned space flight, $107,750,000; vehicle sys-

tems technology, $21.2 million; propulsion technology, solid rockets, $2.8 million; liquid rockets, $63 million, nuclear systems technology, $10 million; space power technology, $8 million.

VEHICLE DEVELOPMENT

Then we get down to the specific development of your vehicles: DELTA, $12.5 million.

Dr. DRYDEN. The list of vehicles was put in to show the 1959 and 1960 obligations under the same headings.

Mr. THOMAS. CENTAUR is $47 million, and the big one, SATURN, $134,308,000; then your tracking and data acquisition, $32,550,000. It totals up to $621,453,000 against $320,350,000 last year.

Mr. OSTERTAG. Will you yield?

Mr. THOMAS. Yes.

Mr. OSTERTAG. Does that mean there has been no money appropriated or available for SATURN before this time?

General OSTRANDER. These were carried under other agency funds, ARPA primarily; $27 million in 1959 and $77 million in 1960 was funded by the Department of Defense; 1961 is the first time we pick up the full-year funding.

Mr. OSTERTAG. This is the first funded money to your agency for this program?

Dr. DRYDEN. That is correct. These numbers are the same numbers you saw on the charts in connection with the presentation.

Mr. OSTERTAG. Where do we find transferred money on that?

Mr. ULMER. This does not show in our funding, sir.

The language sheets under each appropriation indicate the comparative 1959 and 1960 amounts in the DOD budget.

Mr. OSTERTAG. What I was trying to get at is, is there some place for determining what the SATURN program is costing from the beginning?

Mr. THOMAS. You got some transferred funds for SATURN, did you not?

Dr. DRYDEN. Not yet. The unexpended balances will be transferred to us on June 30, 1960.

Mr. THOMAS. $55 million.

Mr. OSTERTAG. It is on page 193, $55 million.

Dr. DRYDEN. That is the R. & D. part of the 1960 DOD SATURN funding. The unexpended balance of that amount will be transferred at the completion of the formalities of the transfer, on June 30, 1960.

Mr. OSTERTAG. In all other programs you show a figure under fiscal 1960, on the tabulation on page 109, but SATURN is conspicuous by the absence of any figure.

Mr. THOMAS. It was funded by the Department of Defense until about 1961.

Mr. ULMER. It would have been helpful if that had been put in. This is one of the omissions Mr. Thomas mentioned yesterday.

UNOBLIGATED AND UNEXPENDED BALANCES

Mr. THOMAS. What will be your unobligated balance at the end of the fiscal year of your 1960 funds? With your supplemental you have $320 million in 1960, do you not?

Mr. ULMER. That is the total R. & D. will have this year, Mr. Thomas.

Mr. THOMAS. What is your unobligated as of January 1 and what will it be at the end of the fiscal year?

Mr. ULMER. The unobligated balance on January 31——

Mr. THOMAS. Any recent figure you have.

Mr. ULMER. $105 million.

Mr. THOMAS. What will it be at the end of the fiscal year?

Mr. ULMER. This would have to be an estimate. It could run somewhere in the neighborhood of $10 or $15 million.

Mr. THOMAS. More than that?

Mr. ULMER. Our amount last year, I think, was somewhere in the neighborhood of $20 million out of the 1959 appropriation.

QUESTION AS TO SLOWDOWN OF PROGRAM AS RESULT OF REDUCTIONS FOR 1960

Mr. THOMAS. It was said around here by one of your prominent staff members that $6 million slowed you down a year on one of your prime projects.

Here you had an unexpended 1959 balance of $20 million. You transferred from 1960 "Research and development" funds to "Construction funds," $15 million. Here you come up with $35 million. You are howling over $6 million. What kind of bookkeeping is that and what kind of loose language is that?

Mr. HORNER. I think you are referring to my remarks.

Mr. THOMAS. I shall read them to you if you want me to.

Mr. HORNER. I have discussed that particular project at considerable detail with the House Space Committee. Although the funds you refer to were not spent and not obligated——

Mr. THOMAS. You were claiming that it slowed down the project for a year or a year and a half.

Here you had $35 million you did not use. Where did it slow you down?

Mr. HORNER. We cannot commit funds until appropriated by the Congress.

Mr. THOMAS. They were appropriated last year.

TRANSFER OF FUNDS FROM RESEARCH AND DEVELOPMENT TO CONSTRUCTION

You took from those appropriated funds, $15 million, "R. & D." and you transferred it over to "Construction."

Then you got a supplemental. You did not even use that. What becomes of your language then that it slowed down 12 months as a result of this $6 million?

Mr. HORNER. The transfer authority and the supplemental funds were both used in support of Project MERCURY, which is our highest priority project, in which we are trying to retain a schedule.

Mr. THOMAS. You transferred that money out of "R. & D." over into "Construction," so if it was your highest priority, why did you not use it for that?

Mr. HORNER. That was a subsequent decision. The construction involved was also for the MERCURY project. It was an emergency reprograming needed at that time to prevent slippage on the construction of the tracking network for MERCURY.

Mr. THOMAS. It will be 36 months before you use it.

Dr. DRYDEN. Unless the construction is started now, it won't be ready in 36 months.

Mr. THOMAS. Which is more important, to get the engines started or what?

Dr. DRYDEN. The F–1 engine about which you are speaking does not have the top national priority. I wish I could tell you, Mr. Thomas, that when we do not get the money we asked for we can still do the same amount of work. Unfortunately, this is not true and the decisions we have to make when we do not get the funds that have been estimated have to be based on doing the important things.

Mr. THOMAS. Here is $35 million that you had that you did not use.

Dr. DRYDEN. This money was committed.

Mr. THOMAS. I think you made a statement that $6 million had slowed down the project for a year or a year and a half.

Dr. DRYDEN. Yes.

Mr. THOMAS. You had $35 million.

Dr. DRYDEN. Mr. Thomas, we are all familiar with the process of this long lead time work that you have met in the Defense Department many times.

Although there are uncommitted funds in the sense that on our books there is no piece of paper outstanding against them, they are committed to the projects that are going on.

Mr. THOMAS. You make your own books. You had the money. You cannot jump those figures. You did not use them.

Yet you went around and said it slowed you down. You didn't say it. It was said by your organization. It slowed you down 12 months when you had the money. If you did not use it properly that is nobody's fault except yours.

Dr. DRYDEN. I think what was said was that when we do not have enough money to cover all the needs, we take care of the projects which have the highest priority. The things which suffer are those that are needed farther off.

PRIORITY OF PROJECTS

Mr. YATES. Is it all right to find out if there has been a schedule of priorities established?

Dr. DRYDEN. The MERCURY and SATURN projects have the highest national priority, exactly the same priority as the ballistic missile.

PRIORITY STATUS OF F–1 ENGINE

Mr. YATES. Is the F–1 a priority?

Dr. DRYDEN. It does not have that priority.

Mr. YATES. Does not the F–1 engine have a priority and is it not a part of those projects?

Dr. DRYDEN. No, sir.

Mr. YATES. For what is the F–1 engine to be used?

Dr. DRYDEN. It is to be used in the vehicle which goes beyond the capabilities of the SATURN and which will enable a manned landing on the moon and return. This is some years in the future. If we have to slow anything up, this is where we have to take the money from—our longer range items. This is what any prudent person does. In other words, we have to take care of the immediate needs now.

Mr. YATES. When you talk in terms of this being in the future, I am somewhat confused for the reason I was under the impression that you had an urgent program for trying to find an engine with great thrust.

Dr. DRYDEN. SATURN gives us this 1,500,000-pound capability at least 2 years earlier than you can possibly do it with the F–1 engine.

Mr. THOMAS. Doctor, what Mr. Yates is getting at is that you are in the constant process of reprograming and rescheduling.

Dr. DRYDEN. This is quite true.

Mr. THOMAS. What you may need today, you will change your mind on tomorrow. We give you that latitude.

Dr. DRYDEN. That is correct.

Mr. THOMAS. You canceled out VEGA to the tune of $42.8 million and you only obligated $18 million. So, there is another $30 million that you had all the latitude on earth to use.

Dr. DRYDEN. We had the latitude to choose, I admit this. I say we made the choice to take this from the F–1 engine. That is the only statement that was made. There is no criticism of anybody in this as far as I am concerned. We have to live within the resources you give us, and we cannot go beyond that.

Mr. THOMAS. You had more funds than you needed and if you did not use them properly, that is the fault of no one but yourself.

We do not like your going to another committee and saying because you did not get $6 million, when you had $35 million or $40 million, it slowed your program by 12 or 15 months.

ALLEGED INCREASED COST AS RESULT OF PROGRAM SLOWDOWN BY NASA

Mr. YATES. In addition to that, Mr. Chairman, I understand it goes even further than that—that as a result of the slowdown of the program, it will be more expensive by $13 million.

Mr. HORNER. Anything you slow down and stretch over a longer period of time is always more expensive.

Mr. YATES. Is my information correct? I understood that someone testified before the legislative committee that as a result of the slowdown the additional cost to the Government for the same program would be an additional $13 million. Is that not substantially correct?

Mr. HORNER. I do not recall that figure being used in the testimony, but it is inevitably correct that things which you do over a longer period of time with American industry costs more than if you do them at the time of the original schedule, because they have their working organization and facilities which are set up to do it on a given schedule. When you stretch out the funding process, it is extremely difficult for industry to reduce overhead facilities and reduce workers. So it always costs more.

Mr. YATES. What will the additional cost be as a result of the slowdown?

Mr. HORNER. I would have to provide you with that information.

Mr. YATES. Was no such information given to the staff of the space legislative committee?

Mr. HORNER. The information may have been given by someone in the Agency.

Dr. DRYDEN. Perhaps Mr. Gleason could answer that.

Did we give the increase in cost because of the change in schedule?

Mr. GLEASON. No, sir.

(The following was submitted later for the record:)

Information was given to one of the legislative subcommittees that the increased cost was $13 million. It is actually nearer $8 million.

Dr. DRYDEN. Many of our people appeared before the other committee, and it is possible that somewhat lower down in the organization someone gave a number.

Mr. YATES. You do not know now what the additional cost will be?

Mr. HORNER. At best it would only be an estimate at this time. We have not completed the negotiations with the contractor as to the reduction of this year's appropriation.

Mr. YATES. Could it be as much as $13 million?

Mr. HORNER. It could be; yes, sir.

Mr. YATES. Could it be lower or more than that?

Mr. HORNER. It is possible.

Mr. THOMAS. Well, if it is, you brought it on yourselves because you had the money.

Mr. HORNER. No, sir, Mr. Chairman; we did not have the money.

Mr. THOMAS. I think the record will certainly clearly indicate to the contrary, when you transferred money out of your research and development fund. No one made you do that. You did that on your own.

Dr. DRYDEN. We take the full responsibility for the decisions which had to be made.

Mr. THOMAS. And, you gave something else a higher priority than this project but, then, you said this project suffered because of that.

Dr. DRYDEN. It suffered because we did not have the money to put on that project. I do not mean to imply any criticism of anyone. We have always lived within the funds you have provided, and we have to make this kind of decision every year. I do not know a year when we have not had to make such decisions, or any other agency of the Government, for that matter.

SUPPORT OF NASA PLANT

Mr. THOMAS. Let us look at your support of your plant item in the amount of $51,345,000 this year as against $22,684,000 in 1960 and $1,097,000 in 1959.

These funds provide for transportation expenses, leased communications lines, contractual services, repairs, alterations, minor construction and supplies and materials as well as equipment used in the operation of all your installations?

Dr. DRYDEN. Yes, sir.

INVENTORIES

Mr. THOMAS. How much inventory are you carrying? What is your sum total of inventory of expendable materials at your laboratories and installations?

Mr. ULMER. It is running somewhere between $3 million and $4 million.

Mr. THOMAS. You have more than that down at Huntsville.

Mr. ULMER. The figure I gave you is exclusive of Huntsville. I beg your pardon. We are in the process of negotiating with the Army the split of the Huntsville inventory which will come to us.

Mr. THOMAS. How much inventory do you have at one of your older installations, for instance, Ames or Langley or JPL?

Mr. ULMER. Three million to $4 million covers all of those installations. At Ames I would guess it would be somewhere in the neighborhood of $300,000. I would be glad to break it down for you.

Mr. THOMAS. Your inventory is quite small then, is it not?

Mr. ULMER. It is relatively small.

Mr. THOMAS. How often do you turn it over?

Mr. ULMER. I think we run on about a 3 to 4 months inventory, as a rule, on expendable supplies.

Mr. THOMAS. I notice you have set up for Plumbrook this year $10 million.

How did you arrive at that figure of $10 million?

It is not in operation yet, is it?

Mr. ULMER. Mr. Thomas, I am at a loss to find that $10 million figure. The Lewis Center has $9 million for support of plant.

Mr. THOMAS. Let me see if I can find it some place. It could not have been $10,000, could it? We do not deal in such small figures. It is $10 million.

Mr. ULMER. The $9 million, "Support of plant for Lewis," includes the Plumbrook operation.

Mr. THOMAS. Where is that figure of $10 million. It may not be under "Support." It is not under "Support." I misled you if I indicated it was under "Support."

What was the $10 million for at Plumbrook?

NUCLEAR SYSTEMS TECHNOLOGY

Mr. ULMER. We have a nuclear systems technology project in R. & D.—a line item program for $10 million.

Mr. THOMAS. Please explain that.

Dr. DRYDEN. That is a contract with outside groups in the development of nuclear technology; $5.5 million, which is in this sum, is for the support of Project ROVER, and the contracts that will be made for the development——

Mr. THOMAS. Put your finger on it. There is not a clear justification of the breakdown of it.

Dr. DRYDEN. This was presented to you in great detail the first day by General Ostrander, with the individual items in short form.

Mr. ULMER. On page 180–1 is a detailed writeup of that program.

Mr. THOMAS. I believe it starts on page 180 and goes through 180–5.

It is $10 million as against $6 million last year as against $3,810,000 in 1959. No; that is the electric generator.

Mr. ULMER. That is also a part of that program.

Mr. THOMAS. Where and how are you going to spend this? Is this under "Research contracts"?

Dr. DRYDEN. No, sir. These are contracts with industry for development. The pump development in support of ROVER, which is a contract——

Mr. THOMAS. Is that in the amount of $1.2 million?

Dr. DRYDEN. That contract is with North American.

Mr. THOMAS. The turbopump system development is in the amount of $1.5 million, I believe.

Dr. DRYDEN. Yes, sir.

Mr. THOMAS. Hydrogen-cooled jet nozzle is in the amount of $800,000 and your liquid hydrogen and propellent supply is in the amount of $800,000.

Dr. DRYDEN. The last is the supply of liquid hydrogen to the ROVER test that we mentioned.

Mr. THOMAS. Where is this research carried out and by whom?

Dr. DRYDEN. This is not research. This is hardware development. This is the ROVER reactor test which you heard about, and there will be a later test this summer which is a development leading toward a breadboard nuclear rocket engine.

The AEC, as we mentioned, has some $20 million for the reactor development, and these are the sums which we carry to do the nonreactor part of the test setup, and we furnish the liquid hydrogen to them.

Mr. THOMAS. I have this language here underlined:

> Although early emphasis in the nuclear heat transfer program was on research aimed at the development of a large thrust, the current developments of the program are aimed at accumulating the necessary research information required to develop a reactor flight test system, launched by chemical rocket.

Dr. DRYDEN. That is right; since NASA assumes the responsibility for the ROVER program.

Mr. THOMAS. Where is the other $5.5 million? You set out four different programs which in just round figures do not mean anything.

Dr. DRYDEN. If you continue with that same table, you will find the other item in the sum of $1.2 million on the next page, page 180–5.

Mr. THOMAS. For your reactor test in project ROVER support, you have the sum of $4.3 million. For applied research on nuclear rockets you have the sum of $1 million.

Dr. DRYDEN. And the breadboard engine design is in the amount of $200,000. This is the presentation that was made the other day.

Mr. THOMAS. Who receives the $1 million and how did you arrive at that?

General OSTRANDER. The $1 million is concerned primarily with applied research to do our portion of the ROVER project.

Mr. THOMAS. Will you do it at your Plumbrook installation?

General OSTRANDER. Some of it may be done there.

Mr. THOMAS. We have not found any use for Plumbrook. I am doing my best to help you find some use of it. We have about $11 million tied up in it.

Mr. ABBOTT. I think I supplied some uses of it yesterday.

Mr. THOMAS. Mr. Abbott, you are the best man in the house.

Mr. ABBOTT. Plumbrook is used for more basic research.

Mr. THOMAS. You mean it is going to be used, but it has not been used yet?

Mr. ABBOTT. That is correct. As I described yesterday, one of the first projects in it will be this matter of radiation damage to metals at high temperatures.

Mr. THOMAS. Where are you going to spend this $1 million right here?

Mr. ABBOTT. I am not going to spend it.

General OSTRANDER. This $1 million is in my program, Mr. Thomas, and $300,000 of it is primarily to design the vehicle which will eventually use the ROVER project. This we will spend primarily at Aerojet.

The next one is on radiation effects at these low temperatures that we deal in with atmospheric cover, largely to be spent with industry, and probably with Lockheed.

Mr. THOMAS. We had these dollar-a-year contractors at Hanford and at Oak Ridge, and we had all these laboratories at Argonne, one in New York and one in Iowa, and two or three more scattered around. Why do you have to go to industry for this?

Is not the Atomic Energy Commission effective in this field, and does not the Atomic Energy Commission know more about this field than industry knows?

Dr. DRYDEN. Actually, AEC is technically directing it.

Mr. THOMAS. Why do you not do it in your own Plumbrook installation?

Dr. DRYDEN. Let me use an illustration which I think is more familiar. The General Electric Co. has a research laboratory at Schnectady, N.Y., and they have development plants for various products in various other cities. Plumbrook corresponds to the research laboratory at Schnectady which is doing the advanced research which the manufacturing plants will later apply. The work that General Ostrander is putting out to industry is the hardware development which will give us an engine to fly—a rocket—and this is developed using the information from the research activity which produces knowledge about materials and shielding.

General OSTRANDER. We will take the results of the work at the Plumbrook facility and use this in specifying the specific work that we want done with industry toward the design of a complete nuclear engine and vehicles to be propelled by it.

Mr. THOMAS. Is not the Atomic Energy Commission doing the same assembly work in its various laboratories?

Dr. DRYDEN. They are not in the rocket business or the space propulsion business; they are in the development of nuclear reactors and they will develop and contract for the nuclear reactors that go into this engine, but the nuclear reactor is only a small part of the engine. The power conversion devices and the gadgets for pumping the propellent fluid—those are our responsibility.

Mr. THOMAS. And you cannot get them to do this research for you?

Dr. DRYDEN. Well, the AEC is spending $23 million on the reactor and at the moment we are supporting it with $5.5 million. Three years from now we are going ahead with the development of this engine and we will be spending $30, $40, or $50 million or more and the AEC will be supporting it.

STATEMENT OF DR. VON BRAUN ON THE SATURN PROGRAM

Mr. THOMAS. Dr. von Braun, tell us about your SATURN program. How are you getting along, what are your many headaches, and what are your hopes and aspirations?

Dr. VON BRAUN. We consider the SATURN project as a project of greatest national importance and urgency because we think it is our only bet to beat the Russians in the payload capability.

I think we have proven that in the payload area and also the capability of obtaining high speeds we are probably almost on a par with the Russians today; in fact, this transmitting equipment beats anything the Russians have even tried to do.

However, in the big rocket area, in the booster area, we are still definitely behind.

Our opinion is that the SATURN booster is at least twice as powerful as the most powerful booster the Russians have thus far employed. We do not know, of course, what they are developing.

The SATURN booster is powered by four H–1 engines of 180,000-pound thrust each through the center which are rigid mounted, and four other ones outside which are swivel mounted. Only the outer four are used to control the vehicle.

All motors run on VP and liquid oxygen. The fuel is stored in four of these outside containers. Liquid oxygen is stored in four others, plus one central container.

All containers are interconnected so that we can continue to fly even if any one of the engines goes out.

This entire thing is only the first stage of the entire SATURN vehicle.

Prior to launching the vehicle rests on eight of these outriggers which also serve to transmit the thrust of the engines to the rest of the vehicle. These little rockets have to do with the recovery of the booster. I will come to that particular subject a little later.

The thrust version of the overall SATURN vehicle will be the C–1. The booster is shown again.

The second stage will contain the hydrogen powered section with four power operated Pratt & Whitney engines with a thrust of 20,000 pounds each, total thrust of 80,000. Compared with the 1½ million we get from the eight engines it is a relatively weak second stage.

At the third stage we use more or less the middle CENTAUR vehicle which has essentially the same engines but only two. It propels smaller loads, of course.

This is by no means optimum staging. The upper stage is too light for this powerful booster. We get a payoff because of the high specific impulse propelled economy of this hydrogen fuel, and therefore, despite the fact this is not optimum staging, this thrust configuration of the SATURN carries more payload in orbit.

The ultimate objective is to come up with an optimum stage SATURN vehicle which also uses the high propellant, high energy propellant, and that leads us to the C–2 configuration which you see here.

This has a brandnew second stage inserted between the former second stage and the third stage, but in order to power this stage we have to have a new engine. This engine has 200,000 pounds of

thrust, four of them are contained, and since this engine does not yet exist we cannot build the C–2 configuration for quite a while, so there will be an interim C–1 capability, and final capability called C–2.

One of the purposes will be to serve as a booster vehicle of the DYNASOAR project. We take the booster and the second stage here and put the winged DYNASOAR on top of this. This is the plan at present.

Mr. RHODES. What fuel will the new second stage use?

Dr. VON BRAUN. Also liquid hydrogen.

In this connection I would like to make a general remark about how the SATURN is faring in general under the NASA Administration.

Immediately after the SATURN project was transferred to NASA, Dr. Glennan appointed a special committee under the chairmanship of Dr. Silverstein to determine this upper stage configuration.

Up to then various competitive ideas had been kicked around, such as just the use of a standard TITAN, perhaps with a CENTAUR top stage, but all this did not look attractive because there would have been a lot of new engineering involved. At the same time the performance was not satisfactory.

The Silverstein committee took up this job of determining the upper stages on the 17th of November, and on December 31, 1959, it came up with a final recommendation. The final recommendation is what you see here, with the C–1 and C–2 configurations.

Dr. DRYDEN. This was a committee with Defense membership. It was a joint committee of NASA and Defense to make this decision.

Dr. VON BRAUN. I also would like to point out that we were happy to be represented on that committee and we were very happy with the final recommendation. In fact, it was a unanimous choice.

On the other hand, we should point out this is a bold choice because liquid hydrogen is a brandnew propellant and has a lot of characteristics we are not too familiar with, so it is a bold choice, but the payoff will be great.

Beyond the C–2, the basic SATURN booster has further growth potential if we combine it with the nuclear upper stage.

The subject was discussed previously. So far on that program, of which 75 percent is supported by AEC and 25 percent by NASA, basic studies have been carried out in using high temperature reactors as heating sources for nuclear rockets.

These nuclear rockets work essentially as follows: There is a big tank of liquid hydrogen. Down here we have a reactor. Attached to the reactor is a nozzle, and the reactor has a great number of graphite tubes going through the reactor. These graphite tubes serve partly as moderators and partly as a guide and heat transfer for the liquid hydrogen pumped through.

As a result the liquid hydrogen enters the reactor cold but leaves it at a temperature of several thousand degrees and reenters through the nozzle.

Such a motor has twice the propellent economy. We usually figure 900 seconds. This is only 120. This is a little more than twice as good.

As a result such a nuclear upper stage can vastly increase the overall payload.

In principle it is possible to fly this right from the ground, but there are certain disadvantages to it. First and foremost there is the prob-

lem of tremendous radiation in the vicinity of the launching site. This runs at a thousand megawatts and you would have gamma radiation in the vicinity requiring very thick concrete shielding for the crew and probably within a mile or 2 miles from the takeoff nobody can stay because there would be a radiation hazard.

In addition, if the thing aborts in the pad area we might as well evacuate the pad and forget it for the rest of our lives and build another one because of the contamination of the area.

For this reason there is some advantage to firing such nuclear rockets only after they have left the atmosphere.

In fact, it is possible even to fire it after the first two stages have brought it up to orbital speed. In this case the tankage must be reduced for optimum payload.

This chart shows the payload capabilities of the various configurations.

C–1 is a two-stage vehicle, orbits 24,700 pounds in the 100-mile orbit and 22,000 in the 300-mile orbit.

In the three-stage the payload is approximately the same. In the third stage there is an escape capability and a capability of reaching the required speed to put 4,500 pounds in a 24-hour orbit or make a soft lunar landing of about 2,400 pounds.

The C–2 gives us a payload almost twice as high all the way around. It reaches 45,000 as compared to 22,000. The escape is 15,200. The 24-hour orbit is 9,000, and lunar landing is about 5,000 pounds.

In the four-stage the payloads for the very high speed missions are even better. This 24-hour orbit increase may be very important.

In the nuclear upper stage the payload would go up to 72,000 in a 300-mile orbit, 45,000 escape, 32,000 in 24-hour orbit, and 14,800 for a soft landing on the moon, so this is a very sizable payload. It makes it definitely possible to fly a portion of this back to the earth so you can bring samples back from the surface of the moon.

Mr. YATES. What is the date of the last one?

Dr. VON BRAUN. The launching date? I would say this is 1968 or 1969.

Dr. DRYDEN. Toward the end of this decade.

Dr. VON BRAUN. We propose to recover the SATURN booster. In normal mission it attains a maximum shown here. It goes through a ballistic trajectory of 200 miles. We enter the atmosphere at about mach 5, so by working it through a cluster of larger parachutes we can lower this into the water and bring it in at low speed.

There is also a contact fuse attached to it which will be dropped down toward the water in a line, and when the contact fuse hits the water the booster will still be about 100 feet up.

This then fires eight solid rockets to take the residual rate of descent out so at the moment it hits the water the speed is theoretically zero and it would ease into the water like a helicopter.

In reality, of course, it will not do that because there is always a wind blowing and horizontal velocity component comes into play.

The booster ultimately will float on its own tankage. While we do not believe all we have to do is to put it back on the pad and fire it again, we feel that the payoff in dollar value will be high enough to warrant this method.

The equipment costs about $250,000, including the operation itself, and the recovery of hardware, particularly engines, will be much more than that.

Here is just one more picture which shows what one can do with the SATURN in the field of large payload capability. One, of course, is that one could send a capsule fashioned after the present MERCURY capsule, perhaps one for three people. Attached to that capsule could be a sort of caboose where the men could work and live for, say, 2 weeks or so, and do all sorts of research work in outer space.

When they want to go back to the atmosphere they can crawl back into the capsule, detach the caboose, retard their speed somewhat, and go back into the atmosphere.

We in Huntsville would not build this. Another thing we can do with these SATURNS is to develop an orbital refueling technique.

Suppose two SATURNS would bring up as payload liquid hydrogen in the upper stages, and a third vehicle already had been brought up into orbit with a burned out third stage and perhaps an empty fourth stage.

By transferring liquid hydrogen from these tanker rockets into the center one we can refuel this rocket so that it can take off from an orbit and go all the way to the moon, land there, and still have enough fuel left in the stop stage to fly back to earth.

In this fashion it is feasible to use even the SATURN with this orbital refueling technique to land people on the moon and bring them back.

Mr. OSTERTAG. That is the theory of bringing them back?

Dr. VON BRAUN. This stage would be needed to impart the necessary speed, to increase the circular orbital speed to the transfer speed going to the moon.

After this speed has been reached the rear stage would be detached, and the unit will land on landing gear, burning up in this stage, and there would be a separate rocket, preferably with storable propellants, used to fly it back from the moon again, and the passengers will arrive in the nose of the upper stage.

Here again this forward end would probably be handled by JPL as NASA's agent. We will provide the projection vehicle for the mission.

This chart shows what the increase in the funding does to the SATURN schedule.

You may remember in fiscal 1960 the SATURN program had $70 million. In fiscal 1961 the request was $140 million.

On this funding level we had promised one firing in 1961, two firings in 1962, three firings in 1963, and four firings in 1964, making a total of 10. No. 11 would have flown in early 1965.

We have always said we need 10 R. & D. vehicles before we can talk about a reasonably reliable operational SATURN, so early 1965 would have been the operational readiness date of the SATURN system.

With this additional funding of approximately $90 million which Congress is now considering, and a small increase of one and a half million dollars in 1960 to enable us to work overtime between now and the 1st of July, we can make this program, still only one vehicle in 1961, but three in 1962, five in 1963, and one early in 1964, so that

again in about the second quarter of 1964 we can fire No. 11, so we have gained a flat year here through this increased funding level.

I would like to mention in this connection that there are other areas where help is needed. One is priority, and very soon after NASA had taken over the SATURN project we succeeded in obtaining the extra priority for which we had been fiighting a long time. This will help a great deal in this area.

As small as this amount is, one and a half million dollars more in 1960, it helps us a great deal toward putting our shop and test facilities in overtime.

Dr. DRYDEN. That has been authorized.

Dr. VON BRAUN. Another thing that NASA has done, immediately upon taking over the SATURN program, is the initiation of a development contract for the engine for the C–2 stage, the 200–K liquid hydrogen engine. Several proposals had been received and the evaluation teams are presently evaluating this proposal. It can be expected that a contract will be let in the very near future.

Money for this engine also has been provided in the 1961 budget.

In more detail this firing schedule will look as follows: We do not propose to fire complete three-stage SATURN vehicles right from the outset.

The very first flights are as follows: One flight in 1961, and two flights in 1962. They will be first stage only with the dummy second stage and a dummy third stage.

In the fourth flight, which will take place in the latter part of 1962, we will have a live second stage with four of these 200–K hydrogen-oxygen-operated CENTAUR engines. Two more of these will follow in early 1963.

In the latter part of 1963 there will be one and then two in the last quarter, full-fledged three-stage flights with a C–1 configuration.

Therefore by the end of the 1st quarter of 1964 the first 10 C–1's will have been fired, giving us this capability of firing the 11th in the 2d quarter of 1964.

So far as the C–2 is concerned, we are limited by the capability of the availability of this engine, this 200–K engine which will take several years to develop. We have cautiously assumed that this engine will be available for flight tests around the end of 1964, enabling us to fire the first live vehicle in the third quarter of 1965 with the C–2, actually two flights in 1965.

Since the C–2 version uses the same stage that we have in the C–1 second stage now as the third stage, the third stage is already set. The fourth stage is identical with the third stage of the C–1, so the real new problem is the new large second stage for the 200–K engine, and therefore we believe with two more vehicles we can round out the entire program.

This about winds up my story, sir.

Mr. THOMAS. Thank you very much. That was most interesting and we have been delighted to have you.

Dr. Pickering, do you have a statement about JPL and what you are doing?

STATEMENT OF DR. WILLIAM PICKERING ON THE JPL PROGRAM

Dr. WILLIAM PICKERING. I would like to talk a little bit about the JPL program and how we fit into this picture.

Specifically, as you know, we have been assigned the responsibility for the lunar programs.

(Discussion held off the record.)

Dr. PICKERING. What I would like to indicate here is the sort of spacecraft development program you get involved in as you move through the series of vehicles which become available.

For example, we have first the ATLAS-AGENA B which is the first vehicle to be used for these missions.

Then we move to CENTAUR and SATURN.

As Dr. von Braun said, SATURN gives you payload capabilities on the order of 10,000 pounds for the moon.

CENTAUR is on the order of 1,000 pounds.

The ATLAS will be on the order of 500 pounds. You go from 500 to 1,000 to 10,000 pounds.

In all of this program, what we are looking at is the development of the unmanned vehicles, so we ask ourselves what the engineering problems are we have to solve looking toward the application eventually of manned flight to the moon and beyond.

In connection with this type of vehicle which we are looking at we run into a variety of engineering problems of increasing complexity as the spacecraft are developed.

This spacecraft, for example, is a simple spinning object in space. For almost any of these missions, we have to do better than that. We have to stabilize the spacecraft in space, we have to point it toward the sun, we have to maneuver it, land it, we have to point an antenna on the spacecraft back toward the earth, so you have a spacecraft which is capable of doing, in fact is required to do, many different things.

As we go through this we see an evolution of spacecraft complexities, a family relationship right through the series.

First we have the lighter ones, relatively simple, lunar soft landing and precision lunar soft landings.

In order to do this, then, we find a requirement of building a device which speeds the complexity of the ballistic missile—rockets, guidance, communication, and television. All of the sorts of things which you see in ballistic missiles are involved, so your spacecraft can be quite complicated devices.

I think the history of the jet propulsion laboratory in this area is very appropriate for this kind of problem because we have, over the year, built up a capability in the broad spectrum that we need for a complete ballistics missile system. All of those skills are available at the laboratory for this job.

I should like also to point out the leadtimes required in this sort of program. For example, right now we are starting in on the program of these vehicles. Before the end of the year we must start in actively on the CENTAUR program, and before the end of 1961 on the SATURN program. So long leadtimes are involved. There are commitments to be made which have to mesh with the vehicle availability which Dr. von Braun discussed.

In the case of the planetary program. we have much the same sort of picture, except here we are restricted in the launch dates. You are limited in the amount of energy available and the time to travel to the planets, and then there are only certain times when a planet and the earth are in positions that allow you to fly to them.

It turns out, for example, that toward the end of 1963 you have an opportunity for firing to both Mars and Venus. After that, about every 14 months to Venus and Mars. So you have the opportunities shown here.

Furthermore, the actual moment of launching is quite limited. In other words, the payload which you can carry to the planet varies quite considerably as you move away from a certain optimum time of launching. This is an interesting problem in distinction from most all other space problems, in that you have to commit yourself to a firing time to the second when you start on the program. You have to meet that. Otherwise, you have had it.

This program uses CENTAUR for the first series of planetary shots, in the 1962 and 1964 shots. Then we use the SATURN for later shots.

In complexity, the first shot is essentially the modified payload of the ATLAS–AGENA type. Then we go into payloads which will have guidance which will bring them in closer to the planets, and then orbiting around the planet and, indeed, having a capsule which will be thrown off the main body of the space craft and will land on the planet. In the process it will transmit information to the main body of the space craft, which in turn will rely it back to earth.

"Vicinity" means within a million miles, a "near miss" about 100,000 miles, and "orbit" about 1,000 miles.

In order to carry on these programs, of course, in addition to the vehicle and the spacecraft, one needs the communications system. It does not do you any good to place something out in space unless you can talk to it. As discussed earlier, one of the tracking networks is planned for this purpose. There are three stations 120 degrees apart around the earth with which we can maintain continuous contact with lunar or planetary vehicles, so we can get information from the vehicles and transmit from earth to the vehicles. That spacecraft will be such as to allow us to communicate with the vehicles at distances of tens of millions of miles. We can transmit in the vicinity of Mars and Venus in the 1962 period and, as time goes on, we will be able to transmit a greater amount of information.

(Brief recess.)

Mr. THOMAS. Doctor, will you proceed, please, sir.

Dr. PICKERING. I should like to point out again that in the case of the planetary spacecraft they have a family resemblance to spacecraft involved in the larger and more complex vehicle. There are many engineering problems to be solved in developing spacecraft which will, for example, do this last task here of flying out to Venus, say, going into orbit around Venus, and throwing out an entry capsule which will land on Venus and make observations as it goes in. It will be a really interesting engineering problem to solve that.

In order to do this kind of thing, we are asking for engineering work of the very highest order—as is true in many areas of this program, of course.

Again I should like to suggest that I believe that at my laboratory we do have a background of experience which covers this field quite well, and it is quite appropriate for this sort of task.

I might also comment that within the present scope of the laboratory we would expect that these two programs would require a very large amount of industrial support. Within the laboratory program we are primarily interested in the advanced engineering and scientific problems which must be solved. Much of the development work will be handled by industry and, in fact, complete system responsibility may be given to industry in some areas. So we will require heavy industrial support to complete the task.

Again I should like to say that the task also involves a great deal of systems planning. One has to integrate the vehicles which Dr. von Braun's laboratory is building with the spacecraft, the scientific instrumentation, the tracking capability. All of this must be working together in order to accomplish these missions. Deep space instrumentation facilities play a very important part in the operation.

Mr. THOMAS. Thank you very much.

Dr. SILVERSTEIN. Mr. Goett, of Goddard, has a lot of interesting gadgets he could point out to you if you would care to take another minute or two.

Mr. THOMAS. Go ahead.

STATEMENT OF MR. GOETT

Mr. GOETT. First I would like to show you the spectrum of jobs that we find ourselves confronted with at Goddard. Our job is to provide the payloads for the scientific earth satellites, the application satellites which might deal with meteorology and communications, and manned space flight. We are dealing with some 35 of these payloads right now. What you see here is just what we would consider to be a representative sample. I might have put "gear" running across here.

These two are past history. First, the sounding rockets. Since Goddard has been in existence, we have fired some 10 of these. We expect to fire some 80 more during the coming year.

Here is the VANGUARD III which went into orbit last September. While its batteries lasted, for 3 months it gave us some 5,000 readings on the magnetic field of the earth. It gave us information on micrometeorite impact here. There is a little microphone behind this, and this gets hit about once every 3 minutes. It has told us that up there the solar cells will not erode too much because here we have an erosion gage which shows no evidence of eroding. If it did, the resistance would change. It has given us information on the X-ray radiation which exists up there. Here is a sort of functional instrument. This thing is spinning, and it tells us when we are looking at the sun. It tells us the orientation of the vehicle.

The PIONEER V has been described. We had a monitoring-management relationship on this.

Here is TIROS, which will go up soon and will attempt to take pictures of the cloud cover of the earth, which will be used then by meteorologists in order to try to predict weather.

Here is NIMBUS, the second-generation vehicle that we are starting now on the design board and probably some 18 months from now we will expect to get launched as soon as a bigger launching vehicle becomes available.

Here is Project MERCURY, which is the responsibility of one large group in our organization. I think you heard a lot about that several weeks ago.

Now here is an orbiting astronomical observatory, as you can see, of some 3,000 pounds. It is at the forefront of the state of the art. We shall attempt to put astronomical instruments in it and point them at various points in the sky with the accuracy and steadiness of a ground telescope to take advantage of the fact that they are up above the atmosphere.

This is an imposing job, and I think there is no one outfit which can do it all. We do it by a combination of outside industrial help and internal work at Goddard.

During this coming year we shall spend $145 million on this outside contractual help, and some $35 million will be expended on internal work and support thereof. Our philosophy in staffing Goddard and creating its facilities has been that we want to make maximum utilization of such outside help as exists, consistent with maintaining within Goddard a capability in each one of the technical areas so we can knowingly monitor this job.

It would be nice if I could take any one of these satellites and go into detail and tell you how we do this. They vary enormously in complexity and type of management, but they all have the same phases which they must go through.

There is the conceptual design, the choice of mission, and the various ways of doing it. There is the detail design, development and fabrication of components. Finally, there is, you might say, an acceptance test or proof test of the conceptual ideas that went into it to see if we have the right product. There is the operation when you launch and track it. There is, finally, the data analysis and scientific reports.

The major portion of the $145 million that we spend outside is spent in this area. The major portion of the $35 million that we spend inside is spent at key crossroads so we can, let us say, have control of the project.

Rather than going down through these various items here, I should like to take a few typical ones. Under the conceptual design there is the mission selection, in which we cooperate with headquarters. Then certain approaches have to be made. The big thing is the experimental equipment which is to go in there to make the scientific measurements that we want. You appreciate that we are confronted with the problem of miniaturization, making these instruments work in an environment with which we are quite unfamiliar. Design approaches must be developed before you can turn this over to somebody to execute.

I have here a number of the small instruments which really are the heart of things. Here is an instrument which will fly, let us say, in a sounding rocket. This thing will be rotating and this window will look out. Radiation will come in this window. This window will pass radiation only above a given frequency. Inside there is a gas which will be ionized below a given frequency. So now we have a

frequency band here, and any radiation which comes between this band of 1,100 to 1,300 angstroms we shall be able to measure.

We have to be able to measure the electric potential. So here is a Goddard-produced, in a breadboard sense, instrument which will go in here, and a similar one in here, for the measurement of the electric potential.

Here is another instrument. This is just a standard geiger counter. The problem is that you want to count the number of particles which come in here and hit the gas in there, which will be ionized. Instead of measuring the voltage which has been generated or the degree of ionization, we need something which will count, just the number of counts. Here is another Goddard-developed instrument that measures the pulse rate, anywhere from 1 to 1,000 pulses per second.

Mr. YATES. Can you give us any estimate of how much any one of those instruments costs in the course of development? Take the one that the chairman is holding now.

Mr. GOETT. The development is so diffuse and goes so far back, it would be very difficult to say.

Mr. YATES. You have no idea what it is likely to cost?

Mr. GOETT. I am afraid I cannot give an authoritative answer to that.

Mr. YATES. It is not cheap, though, is it?

Mr. GOETT. No.

Mr. RHODES. You do not measure that radiation in roentgens, then, as we do on earth. What is your unit of measure?

Mr. GOETT. Actually, the way you do it is to take this gage off there and measure the ionization, the voltage produced, and then bring it down on the ground and expose it to a radiation on the ground from which you get the roentgen measurement. You get a sort of conversion factor. This conversion factor is just as good as your guess at to what is up there. We need more and more sophisticated instrumentation to tell us that.

Here are a couple of other instruments. Generally we have these objects spinning. We want to know which way they are pointing. Here is the sun cell, which is really a photocell. Every time it passes the sun this will give a pulse which will go into the electronic instrumentation. We know it is pointing at the sun.

Here is an earth cell on the same principle. At any given time when we are measuring the magnetic field we want to know in which direction the vehicle is pointing.

I do not mean to imply that we do all this alone. This particular VANGUARD III was launched last September, and for 3 months gave us good data. The heart of this is the magnetometer up here which, as you can see, is separated from the rest of the magnetic material in the vehicle by this Fiberglas material here. This has given us some 5,000 measurements on the magnetic field of the earth. We can measure within one ten-thousandths of the magnetic field of where we are sitting right here. We measure fluctuations. We are trying to build up a store of knowledge as to the relationship between the magnetic field variations in space and the radiation characteristics in space. It is instruments like these which first must be developed, at least in a breadboard sense, before you can go into this stage, and this is Goddard's job. We do it largely inhouse, but in connection

also with many other people in the scientific fraternity, houses like Varian which work with us there.

Secondly, after the experimenter has developed his instrument, you have to have some means for transmitting this information down to the ground. These rockets which Dr. von Braun builds are not real gentle on instrumentation, so it cannot be a really delicate one.

Dr. VON BRAUN. Monkeys can take it.

Mr. GOETT. On this one here, we had 48 different types of information that we wanted to transmit to the ground, and a very limited amount of weight. The outfit that I inherited, which previously was working at NRL but came over to VANGUARD, developed this. This is the intervening device which goes in between the sensing equipment and the telemetering transmitter down here and takes the information and sort of stores it in a memory core here—this memory core was made possible by a background development on magnetic cores—and then picks it off on each one of these little transistors. It is like a commutator but it is a light and reflective commutator. It is this piece of equipment, the heart of the apparatus, which enables us to get these 5,000 measurements here. This is a service group to the scientific men to help them get their data down to the ground.

The TIROS, which I showed you, will go around the earth and we shall not have the ability to interrogate it all the time. It will pass over a certain portion of the earth and it will store its data on a magnetic tape which you can see here.

This magnetic tape is capable of storing some thousand seconds of information on it and when the satellite comes over one of our minitrack stations, an interrogation signal will come up and in 3 seconds the data will be transmitted back to the ground, put on equipment, and then sent up to the Goddard Laboratory where all this will be decoded.

This also is an internally developed piece of equipment which has become the prototype for other pieces of equipment we are getting designed in other satellites.

This is an intermediate link, which takes the information off there, codes it, and passes it on to the telemetry.

Another aspect of this task, which is too big and so I do not have any samples of it, is that we have to decide which ways and means we are going to use for the control of some of these other vehicles.

Take the orbiting astronomical observatory. We have to do a job here which at least is at the frontier or maybe beyond the frontier of what can be done now. We have people at Goddard who are going around to our research centers to get the advance research information from them which in due course will be designed into this vehicle in order to make it a vehicle that, come 2½ years from now, will do its job.

Passing from the conceptual design, we go to the detail design and development phase. Here, as I say, we do the major portion of it outside—although the smaller, this rocket and this were built completely in the Goddard shops—the larger vehicles we expect will be contracted outside. As a matter of fact, this job here was done entirely on a contracting basis.

Mr. BOLAND. By what shop?

Mr. GOETT. Space Technology Laboratory did this job here.

This also is reflected in our Goddard organization. It is different from my background. Previously, the NACA did it. We have to have a very strong contract monitoring group.

In the first place, we are building up a set of mature technical project managers, and then a very strong business part of the organization to handle the procurement and contract part here. This part of the job has sort of moved up and become of equal importance with us at Goddard in comparison to what it might be at Ames, where I came from.

Next is the payload proof test. We consider this of primary importance. The manufacturing industry has produced the thing. Now, there are a bunch of somewhat speculative ideas in it.

We have to find out how it works, in a prototype sense, and then also we have to make sure that this thing that we are going to put up in flight and with a lot of money behind it will work. We are going to have to subject it to as much ground testing in space environment as we possibly can.

Right now we have adequate capabilities to do this on this small size payload, but we have to look to the future. We do not have the equipment in which we can subject this particular large payload to the environmental tests, vacuum conditions, temperature conditions, radiation conditions—we need this. This is one of the items in our C. & E. request.

Dr. DRYDEN. The question came up as to what payload capacity that equipment would take care of.

From a few hundred pounds to what?

Mr. GOETT. The ones we have now?

Dr. DRYDEN. The equipment you are asking for in 1961.

Mr. GOETT. I know it in terms of size. It is an 11 by 15 chamber. This is what we are presently thinking of. If you want to look forward in the future to when we get to the bigger payloads such as the SATURN will launch, this is not going to be adequate for our total needs, but that is another year.

Mr. YATES. Is it cheaper to build a bigger one first or not; or must you build them both?

Mr. GOETT. Under any circumstances, since you put a payload in there and possibly it takes 4 to 6 weeks to test it, we will need both in the long run and the smaller one will be useful first.

We will always be firing, I think, smaller payloads, though there is debate about this.

Mr. THOMAS. You are working in 1960 on a poyload of 200 to 300 pounds, are you not?

Dr. DRYDEN. Yes.

Mr. GOETT. We need to test components on this.

Getting on to the operation, we furnish a launch crew at Canaveral to work together with the vehicle people. When the payload gets in orbit, our minitrack stations do the tracking and ground data acquisition. You know we had a north-south fence of minitrack stations which was capable of taking care of east-west flying satellites.

On newer stations we are building an east-west fence, which will take satellites that fly in the other direction, north and south.

These are spotted around so that they will be able to track and interrogate the satellites that we anticipate.

As you know, each one of these stations will be connected by communication lines to Goddard. Data will be fed in here, will be translated by IBM machines and the like from the coded type of information that we get into a form that can be analyzed in this final stage by the scientific experimenter. We made a rough check yesterday of these 35 satellites we are talking about and there will be some 50 different scientific experimenters here, a number of which will be at Goddard, a number of others will be out in the scientific community. It will be our job to furnish them the data from these satellites in a meaningful form and then they will produce the scientific reports, which is the end product.

Mr. JONAS. May I ask a question? Not that we need it here, but for other people who will read this record. Can you tell us in everyday language some of the information you have analyzed so far? What information have you gotten back of a practical nature?

Mr. GOETT. This instrument, the magnetometer, has given us information, as I say, on some 5,000 points on the magnetic field of the earth.

Mr. JONAS. What did it give you? What were the points? What did it tell us we did not know?

Mr. GOETT. We are still in the process of analyzing it. We got it last December. It is being looked at to try and determine the fluctuation in the magnetic field of the earth and tie this in with the radiation in the Van Allen Belt. We have to know this in order to explain the buildup of the Van Allen Radiation Belt for one thing, in a scientific sense.

Dr. DRYDEN. Maybe you should talk about magnetic storms, which might be a more familiar concept. I think you know of the disturbances that happen to radio and telegraph communications at certain times.

Mr. JONAS. A lot of people think you folks are causing this bad weather we are having, and the tornadoes that occur with increasing frequency, et cetera.

Mr. GOETT. This is true.

Mr. VON BRAUN. Is he giving you a snow job.

Mr. JONAS. I just thought, if you could state for the record one or two things that we have learned so far.

Mr. TABER. Have we found the atmosphere was rarer and harder to get into than we expected or have we found the other way?

Dr. DRYDEN. It is more dense.

Mr. GOETT. We have established the pressure and density variation in the atmosphere so that in future manned space flight we can design vehicles that will properly relate to it.

Dr. DRYDEN. It was denser than we thought at heights of 200 miles. There is about 10 times as much air up there as we thought on the basis of extrapolation from lower altitudes. You have heard about the radiation belt and the hazard to photographic film, to man.

Mr. JONAS. Did we previously know the extent of this belt?

Dr. DRYDEN. We did not even know it existed until Van Allen discovered it in the data radioed back by the very first satellite that was put up by this country. The shape of the earth has been determined a little more accurately.

Mr. GOETT. I think the other thing that I consider——

Dr. DRYDEN. We have learned that meteorites are much less hazardous than we thought. Before we sent these satellites and probes up, we thought we would be running into lots of meteoric dust. This turns out not to be the case. The particles are very small and you hit one every 3 minutes or something like that.

Mr. THOMAS. Doc, how does that affect the price of beans?

Mr. GOETT. I was about to say that we have gotten information on the existence of the solar wind. Actually, in considering any of man's space flights, the problem is whether the man will get out there and get exposed to, in effect, a wind of these particles which will be fatal to him. We find that aside from the Van Allen radiation belt, there are periodic emissions from the sun which, in manned space flight, we either must totally avoid, or else we must find a way to protect the man from it.

Mr. JONAS. I am going to listen to Dr. Thomas F. Malone talk about meteorology tonight. I thought you might give me a little new information to spring on him, or comments to make that will indicate I know more about the subject than he does.

Dr. SILVERSTEIN. Mr. Chairman, with regard to your question about the price of beans, this is quite interesting: We have been able to make a preliminary correlation on the price of wheat and the activities of the sun. You know, the sun has an 11-year period of activity associated with its rotation and we took the price of wheat over a period of 350 years, working from the existing baseline and only measuring the disturbances from the baseline. Of course, the price reference has changed continuously over this period. We took the fluctuations obtained from data published previously on this factor and correlated that with the sun's activity and showed a correlation. I thought that was pertinent to your remark about the beans.

Mr. JONAS. Are you working on a plan that will tell them how to grow less of it?

Mr. GOETT. Your question of Dr. Malone: Actually, the TIROS is going to go up there and take pictures of cloud cover.

Mr. BOLAND. You have had pictures of that, taken before, have you not?

Mr. GOETT. Not to any great extent, not anything that is meaningful, but we will get these pictures of cloud cover and it will become a meteorologist's research problem as to what is the significance of this cloud cover. We have another instrument that is going in another version that will measure the infrared variations over the surface of the earth, which everybody thinks is of significance in establishing weather.

This is one that will affect the weather. It will give us information, at least, to predict what the weather is going to be. I think that ends my story.

I hope I have given you an idea of the spectrum.

Mr. THOMAS. That is very interesting. Thank you very much. We all know more now than we did before.

Mr. Jonas will be able to spread it on the record tonight with the professor.

I think Mr. Yates had a question that he would like to ask, Dr. von Braun.

Mr. YATES. May I ask you a question, Dr. von Braun?

You talk in terms of saving a year by an additional appropriation. Previous statements I had seen attributed to you had indicated we were several years behind the Russians in terms of engine capability. Will the amount of money that is being requested here help eradicate that lag in your judgment, or should we make more available? Will the provision of more money do it, or is this amount adequate for the job?

Dr. VON BRAUN. I do not believe that we could intelligently spend much more money on SATURN. At least we could do nothing but shall we say try parallel approaches and do this kind of thing that may buy us a little more assurance, but I do not think we could buy time with more money. And to answer your question of whether this is enough to catch up with the Russians, we have to know how fast the Russians are running, and this I do not know.

Mr. YATES. This is true, of course, but you had indicated we were years behind the Russians and while it is true, we do not know how fast the Russians are moving, presumably their rate of progress will be as great as it was in the past. Will our rate be speeded up sufficiently so that in time we can catch them?

Dr. VON BRAUN. Well, I think I cannot go much further than just to say I do not see any possibility of speeding up the SATURN beyond this 1 year, no matter how much money you would swamp on us. One could try a parallel approach and develop another booster and thereby playing it safe in case the SATURN should hit a major snag, but otherwise, I do not see——

Mr. YATES. I am sure your statements in the past made many people feel quite concerned about the gap that exists between the stage of our research and the Russian's. Are we doing enough to catch up, are we doing enough to overcome the lag? When you limit your answer to SATURN, does that cover your entire viewpoint? Do you have opinions as to what we should be doing in other activities than SATURN in order to make up the distance?

Dr. VON BRAUN. SATURN involves, of course, elements such as hydrogen upper stages where very considerable fundamental work must be done which cannot be speeded up beyond a certain space. Beyond that, we hope to go to the nuclear stages, but here again we are confronted with problems where first as Dr. Dryden pointed out, more knowledge must be acquired.

For example, the Plumbrook facility near Cleveland is to provide basic knowledge on reactors and problems like heat transfer in reactors, et cetera:

Mr. YATES. Can I safely say for the record that in your judgment the request that is being made here for the experiments to be undertaken is as much as we can do at the present time?

Dr. VON BRAUN. Yes, sir. I think by and large this is the case. I may add one little remark, though. I was a little frightened when I heard this morning that elimination of our engineering and office buildings for Huntsville is seriously under consideration.

I think if these construction projects at Huntsville would not be approved, this would really set us back.

Mr. YATES. What do you mean "under consideration"?

Dr. VON BRAUN. I had the impression this morning——

Mr. YATES. It is under consideration.

Dr. VON BRAUN. I was very definitely of the impression this morning that these particular projects may be eliminated from the 1961 fiscal year construction program.

Mr. JONAS. Off the record.

(Discussion off the record.)

Dr. DRYDEN. Mr. Thomas has not made his decision yet.

Mr. THOMAS. Thank you, Doctor. You have answered Mr. Yates' question.

Mr. YATES. Thank you, Doctor.

Mr. THOMAS. We have certainly been honored to have you distinguished gentlemen. If you have to leave, thank you for coming and for your fine talks.

SOUNDING ROCKETS

Turning now to sounding rockets, we shall insert in the record at this point pages 147–149 and 149–1 through 149–3 of the justifications.

(The pages follow:)

SOUNDING ROCKETS

Fiscal year 1959	$3,556,170
Fiscal year 1960	8,811,000
Fiscal year 1961	8,000,000

1. Objectives

To determine and understand the composition, structure, spatial distribution, dynamical behavior, and equilibria of the earth's atmosphere; to investigate the interactions of incident electromagnetic and particle radiations with the earth's atmosphere, including solar-terrestrial relationships; to determine and understand the relations between the earth's upper atmosphere and its surface meteorology; and to carry out exploratory geophysical and astrophysical investigations leading to later satellite and deep space probe experiments.

2. Justification

A sounding rocket is a rocket used to carry a scientific payload to a height of up to one earth's radius, i.e., about 4,000 miles. The sounding rocket affords a means of investigating the earth's atmosphere in vertical cross section out to the distance at which the atmosphere merges with the medium of interplanetary space. Both exploratory and routine experimental programs are possible with relatively simple tracking ranges and launching sites. Many investigations of atmospheric structure, composition, ionization, motions, aurora, air glow, absorption of solar radiation, and interactions with cosmic rays and other particles can best be conducted by means of sounding rockets, particularly at altitudes below those at which satellites can remain in orbit. Moreover, many sounding rockets are easily and quickly launched from shipboard or other special sites on short notice for the investigation of sporadic phenomena such as the aurora, magnetic storms, and solar flares. The sounding rocket also provides a means of testing under actual operating conditions equipment intended for later use in satellites or deep space probes, thus providing a check on the equipment before it is committed to the much more expensive vehicles. The current NASA program is based on experience gained from 13 years of rocket soundings, and is a program designed to extend and to fill in the gaps in the knowledge so far acquired on the earth's upper atmosphere and in rocket astronomy.

Operationally, the NASA rocket sounding program divides into three parts: (*a*) "low altitude" soundings up to 100 kilometers (60 miles), (*b*) "medium altitude" soundings reaching to 400 kilometers (250 miles), and (*c*) "high altitude" soundings above 400 kilometers, extending to one or several thousands of miles. Part (*a*) is directed toward completing our knowledge of the lower atmosphere, and includes detailed measurements and synoptic studies of geographical and temporal variations in atmospheric properties, with particular interest in relations of the higher atmosphere to surface meteorology. Part (*b*) involves the study of the high atmosphere, with particular emphasis on the ionosphere and solar-terrestrial relationships. This portion of the program also includes rocket

astronomy. Part (*c*) involves the study of the outer portions of the earth's atmosphere and the fringe regions where the atmosphere merges into interplanetary space. Work in this portion of the program is still in its beginning stages, and measurements in the immediate future will be of an exploratory and survey nature, laying the groundwork for more detailed and precise observations later on.

3. Program phasing

In the fiscal year 1959 a large part of the work was devoted to the analysis of data obtained during the International Geophysical Year. In addition, work was started on the development and preparation of advanced instrumentation for continuing the rocket sounding program. Examples of this instrumentation include the development of a new type of magnetometer and the development of new types of mass spectrometers, pressure gages, and ionospheric instrumentation. During this fiscal year about 35 sounding rockets of the low and medium altitude types were procured for the sounding rocket program. Both low altitude and medium altitude soundings were conducted.

During the fiscal year 1960 the analysis of data obtained from sounding rocket flights is continuing. The medium altitude sounding program is being greatly strengthened and the rate of soundings increased. The development of advanced instrumentation begun in the fiscal year 1959 is continuing. About 75 sounding rockets are being procured and their payloads funded. Most of these are of the fiscal year 1960 altitude range, but some high altitude rockets are included. By the end of the fiscal year 1960 the rate of rocket soundings will attain a level of about 90 rockets per year. A beginning is being made in the performance of outer atmosphere experiments, using such vehicles as the JASON and JAVELIN rockets.

The funds requested for the fiscal year 1961 will permit the continuation of the rocket sounding program at the level of about 90 rockets per year, including purchase of the necessary rockets, preparation of the payloads, and analysis of the results. Development of advanced instrumentation will continue. In addition to continuing the low and medium altitude work vigorously with about 70 rockets, the high altitude soundings will be stepped up, with particular emphasis on the outermost portions of the ionosphere, interactions between the ionosphere and the radiation belt, studies of the aurorae, and studies of the earth's magnetic field.

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Advanced technical development:			
Scientific and technical studies	$220,000	$711,000	$500,000
Development of advanced instrumentation	420,000	2,100,000	1,300,000
Flight research program:			
Sounding rockets	1,383,000	3,100,000	3,200,000
Payloads	1,536,170	2,900,000	3,000,000
Total	3,556,170	8,811,000	8,000,000

OBJECTIVES

A sounding rocket is a rocket which rises to a maximum altitude of 4,000 miles (one Earth's radius) and then falls back to the Earth. The primary use of sounding rockets is for the scientific exploration of the upper atmosphere. Tasks for which sounding rockets are particularly suited are—

1. Direct measurements of atmospheric conditions above the maximum attainable balloon altitude and below the minimum satellite altitude; that is 20 to 125 miles.
2. Measurements of vertical atmospheric cross sections over any altitude range.
3. Simultaneous measurements (synoptic observations) above a number of selected locations, possibly timed to coincide with some unusual event such as a solar flare.
4. Upper air measurements which require a very large payload power level for only a short period of time.

5. Experiments which require the recovery of film after a short exposure at altitudes up to several thousand miles.

Sounding rockets are used to determine the nature, structure,, and behavior of the atmosphere and its interactions with incident radiations and particles, particularly those from the Sun; and to measure radiation arriving from other celestial bodies, from above the obscuring and distorting lower atmosphere which handicaps all Earth-bound astronomers. In addition, sounding rockets are used for the extremely valuable purpose of testing equipment before its use in the far more costly satellites and space problems. The relative simplicity of the launching facilities required by sounding rockets is a distinct advantage. Launchings are planned from the Artic (Fort Churchill, Canada) and from the Southern Hemisphere (Australia), as well as from the NASA facility at Wallops Island, Va., to achieve better worldwide coverage.

The $8 million requested in the fiscal year 1961 budget for the sounding-rocket program will provide for its continuation at about the level established during the International Geophysical Year and maintained in the NASA schedule for the second half of fiscal year 1960 and the first quarter of fiscal year 1961. This level of 90 to 100 rockets per year, as shown in the schedule, will provide for the continuation of the planned research program in the scientific areas of aeronomy (atmospheric physics) and astronomy, which each consume roughly one-third of the rockets; and in the areas of energetic particles, magnetic fields, and ionospheric physics, which each consume about one-tenth of the rockets. The special problems category includes rockets which are used for several scientific areas jointly, or for a project which does not fit into any one of those areas. This NASA space-research program using sounding rockets is coordinated closely with the NASA scientific satellite and space probe research programs, and with the upper atmosphere research programs of other U.S. agencies, to form a unified national program of scientific space exploration.

Sounding-rocket schedule

Scientific area	Fiscal year 1960 (quarters)		Fiscal year 1961 (quarters)			
	3	4	1	2	3	4
Aeronomy	5	6	13	13	9	9
Astronomy	6	8	8	8	6	6
Energetic particles	2	6	2	1	3	2
Magnetic fields		5	1		2	3
Ionospheric physics	2	2	2	2	2	2
Special problems	10	3	3	1	2	2
Total	25	30	29	25	24	24

SCIENTIFIC AND TECHNICAL STUDIES

The sounding-rocket program costs are divided between the advanced technical development and flight research programs. Under the former category is included $500,000 in the fiscal year 1961 for scientific and technical studies. These studies include long lead time theoretical and laboratory investigations of the probable nature of the upper atmosphere and the radiant energy incident upon it. They are based on past experimental and theoretical research, and lead to an increasingly accurate picture of this region of space and to new experiments based on this new knowledge. The funds for the fiscal year 1961 are to be devoted to the areas of upper atmospheric composition and circulation, and of the problems associated with mapping the celestial sources of ultraviolet radiation, which were just discovered during the IGY. It may be noted that the ionosphere and plasma investigations studies which were funded in the fiscal year 1960 have moved directly into the payload area in the fiscal year 1961, because the basic instrumentation development required prior to launching payloads in these scientific disciplines has been completed.

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Composition upper atmosphere	$160,000		
Energetic particles study	40,800		
Gas composition study	19,200	$85,400	$174,500
Winds and diffusion (sodium)		256,000	125,500
Plasma environment measurements		137,700	
Ionosphere current measurements		40,000	
Ultraviolet mapping experiment		100,000	200,000
Ionosphere propagation measurement		91,900	
Total	220,000	711,000	500,000

DEVELOPMENT OF ADVANCED INSTRUMENTATION

The second item under advanced technical development is the development of advanced instrumentation, for which $1,300,000 is being requested in the fiscal year 1961. The decreased amount in this category in the fiscal year 1961 reflects the fact that the fiscal year 1960 program funded much of the basic first generation scientific and technological support instrumentation. As shown in the table, five tasks will be completed with fiscal year 1960 funds, including the $561,000 development of the important nuclear emulsion recovery vehicle (Nerv). Only two new tasks, the development of upper atmospheric wind instrumentation and of an Aerobee rocket aspect control system, will be initiated with the fiscal year 1961 funds.

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Neutron sensors	$100,000		
Magnetometer	75,500		$80,000
Magnetic mass spectrograph	124,500		120,000
Video recorder	120,000		
Telemetering and range instrumentation		$200,000	200,000
Antenna development		50,000	50,000
Dovap development		100,000	100,000
Dovap trailer		20,000	20,000
Development of photographic probe for meteorological study		68,000	30,000
Energetic particle instrumentation for micrometeorite detection system		250,000	70,000
Coronagraph		16,000	20,000
Rocket aspect control system (Aerobee)			50,000
FM transistor telemeters		50,000	50,000
Telemetering and range instrumentation integration		110,000	150,000
Development of ultrahigh vacuum system		120,000	50,000
Development of total pressure gage		50,000	50,000
Upper atmospheric wind instrumentation			50,000
Gas diffusion pump		40,000	
Gas analyzer		20,000	
Atmospheric structure instrument development		195,000	100,000
Sweep frequency receiver		50,000	
Ultraviolet scattering densitometer		50,000	30,000
Design, development, and construction of micrometeorite detection system		60,000	
Rocketborne antenna development		50,000	50,000
Development of Nerv package		561,000	
Development of electrometers		40,000	30,000
Total	420,000	2,100,000	1,300,000

SOUNDING ROCKETS

The fiscal year 1961 amount of $3,200,000 requested for sounding rockets is at about the same level as the fiscal year 1960 allocation. It will be noted that instead of purchasing a few of each type of rocket every year, rocket purchases are concentrated to buying larger quantities of fewer types in any given year to secure the economics of purchasing in larger quantites. This is particularly applicable to the ARCON, NIKE, ASP, and CAJUN types, which cost less than $10,000 apiece, and which are kept "in stock" for use as needed. Approximately 10 percent of the fiscal year 1961 sounding rocket funds are devoted to improvements of the ARGO D–8, AEROBEE 150A, and ARCON rockets which have been found to be necessary for their most efficient employment in the research program. The average cost per sounding rocket is $27,000, which will allow 120

rockets to be purchased with the requested funds. This number provides one backup rocket for every 5 launching attempts, to achieve about 100 successful launchings. The cost per individual rocket ranges from a low of $6,000 for the ARCON, which carries 30 pounds to 65 miles, to a high of $50,000 for the JAVELIN, which carries 90 pounds to 700 miles.

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
20 NIKE-ASP boosters	$50,000		
X-248 A6 rockets	135,000		
12 HONEST JOHN rockets	90,000		
24 NIKE rocket motors	60,000		
5 AEROBEE-100 rockets and boosters	160,000		
7 AEROBEE-300 3d stages	50,000		
15 AEROBEE-HI rockets and boosters	450,000		
20 ASPAN rockets	140,000	$3,900	
5 JAVELIN rockets and 7 vehicles	245,000	68,900	
15 ASPAN rockets		103,500	
22 NIKE-CAJUN rockets		123,200	
2 NIKE motors		5,000	
47 Aluminum-plastic laminate ASPAN rockets		279,500	
4 SKYLARK rockets		150,000	
4 ARGO D-8 rockets		580,000	
6 ARGO D-4 rockets		300,000	
25 AEROBEE-HI rockets and boosters		750,000	
Development of aluminum-cased NIKE-ASP vehicle		480,000	
Improvement and modification of various sounding rockets		103,000	
Development of IRIS-sounding rockets		141,500	
Wind tunnel tests of AEROBEE vehicles		11,500	
35 NIKE-ASP rockets			$332,500
24 NIKE-CAJUN rockets			137,500
5 SKYLARK rockets			180,000
4 ARGO D-8 rockets			560,000
12 ARGO D-4 rockets			600,000
10 ARCON rockets			60,000
30 AEROBEE-HI rockets and boosters			900,000
Design and development of ARGO D-8 payload housing			30,000
Development of improved ARGO D-8 fin			50,000
Development of motor shedding system			150,000
Incorporation of de-spin system for AEROBEE 150-A			100,000
Development of aluminized grain supper ARCON			100,000
Total	1,380,000	3,100,000	3,200,000

PAYLOADS

A total of $3 million is required in the fiscal year 1961 to construct the payloads for the rocket firings in each of the major areas of research: (1) Solar physics and astronomy; (2) energetic particles and magnetic field soundings; (3) ionospheric soundings; and (4) atmospheric soundings. A concentrated effort in solar physics and astronomy is necessary to collect the basic research information required to support the detailed design efforts on the orbiting astronomical observatories (future earth satellites). The rocket studies of primary particles will include investigation of the true nature of cosmic rays from galactic space and the search for new fundamental particles. Further investigations of the nature of the particles creating the aurora will be carried out with rocket flights from Fort Churchill. The payloads for these flights require accurate pointing controls and recovery systems to return films and photographic emulsions exposed to free space. The instrumentation for the ionospheric and atmospheric soundings will include accurate densitometers, ion probes, particle spectrometers, and other experiments to probe the ionospheric region in a systematic manner. Some of these experiments will be selected to correlate with satellite experiments. Special perturbations relating to sudden ionospheric disturbances and explosive warming will also be investigated with rockets.

PROGRAM FOR ROCKET FIRINGS

Mr. THOMAS. This covers your sounding rocket program. The request this year is in the amount of $8 million as against $8,811,000 last year.

I believe you are going to send up 90 this year, are you, Doctor?

Dr. SILVERSTEIN. That is about the number.

Mr. THOMAS. Ten of them will go into the upper stages, or is that figure 20?

Dr. SILVERSTEIN. There will be somewhere between 10 and 20 that will go to higher altitudes.

Mr. THOMAS. There will be 90 this year, including purchase of the necessary rocket, preparation of the payload and development of the advanced instruments, in addition to continuing the low and medium altitude tests with about 70 rockets, the high altitude soundings will be stepped up and so forth and so on.

That is a pretty good program, is it not?

Where will they be fired? Will they be fired from Wallops?

Dr. SILVERSTEIN. Some will be fired from Wallops and some from Fort Churchill.

Mr. THOMAS. I have some language underlined. I have forgotten what it meant.

The current NASA program is based on experience gained from 13 years of rocket sounding and is a program designed to extend and to fill in the gaps in the knowledge so far acquired on the earth's upper atmosphere in rocket astronomy.

How firm is this figure, Dr. Silverstein, of $8 million?

Dr. SILVERSTEIN. This is one area where we have a lot of experience and I think it is quite firm.

ESTIMATED OBLIGATIONS, 1960

Mr. THOMAS. How much will you obligate during fiscal 1960 of your $8.8 million in this program?

Dr. SILVERSTEIN. I think we will obligate almost all of it.

Do you have the figures on the current obligations, Mr. Ulmer?

Mr. THOMAS. After your 13 years' experience, you ought to be getting that unit cost down considerably.

Dr. DRYDEN. It is down. That 13 years of experience includes the experience of the naval research people who are now a part of NASA.

Mr. THOMAS. What about your proficiency showing? You only showed it to the tune of $811,000 this year. Could you not do better than that?

Dr. DRYDEN. I think we have shown a savings.

Mr. ULMER. Mr. Thomas, we have obligated and committed of the $8.8 million, all but $900,000.

Mr. THOMAS. Well, we had better stop or you will have an overrun.

SCIENTIFIC SATELLITES

Let us take a look at "Scientific satellites." We are getting into the money, $41,700,000 against $23,813,000 in 1960, and $21,305,114 for fiscal year 1959.

Dr. DRYDEN. This carries the cost of the vehicles as well as of the payloads.

Mr. THOMAS. I have a little remark. This covers everything.

To determine the nature, extent, and dynamical behavior of the earth's outer atmosphere, and its relation to the medium of interplanetary space; to determine

and understand the nature, extent, dynamical behavior, and causes of the earth's ionosphere.

How far up does the ionosphere go?

Dr. SILVERSTEIN. There are several layers in the ionosphere, starting at a hundred miles and going up to four to six hundred miles, depending on the layer.

Mr. THOMAS. What does the word "ionosphere" mean?

Dr. SILVERSTEIN. It is a charged layer of ions around the earth.

Mr. THOMAS. That is the earth's atmosphere?

Dr. SILVERSTEIN. The earth's atmosphere normally would not be electrified. This layer is.

Dr. DRYDEN. It is just beyond the earth's atmosphere.

Mr. THOMAS. How high up does the earth's atmosphere go, 75 or 80 miles?

Dr. DRYDEN. The earth's atmosphere as it goes up more or less continuously decreases in density all the time. You might say that by the time you reach a hundred miles there is very little atmosphere left.

Mr. THOMAS. Not much to breathe up there.

Dr. SILVERSTEIN. No.

Mr. THOMAS (reading):

The projects under this program support the above objectives by providing for the continuation of a series of exploratory measurements followed by more advanced experiments.

I have the words "figure 8" here.

In the fiscal year 1959 the analysis of results obtained from EXPLORER and VANGUARD satellites was continued. A VANGUARD satellite designed to furnish cloud cover information was placed in orbit.

How many of these are you going to put up? Is this eight here?

The development of advanced instrumentation for the measurement of cosmic rays, the application of accurate clocks to relativity experiments, radio beacons, electron density Langmuir probes, and for the measurement of solar ultraviolet radiation was initiated. Funding was initiated for the purchase of seven JUNO II vehicles and one THOR–ABLE to be used in the launching of satellites. The construction and testing of payloads for these vehicles was initiated.

Dr. SILVERSTEIN. That is the history of 1959.

Mr. THOMAS. That was eight in 1959. I have 11 on the next page. Is this 11 for 1961 fiscal year?

Fiscal year 1961 funds will be used to initiate the funding and procurement of two ATLAS–AGENA B and two THOR–AGENA B vehicles and their payloads, and to procure seven SCOUT vehicles and four payloads.

Dr. SILVERSTEIN. That is right.

Mr. THOMAS. That makes 11?

The SCOUT is a versatile, solid propellent rocket capable of placing 200 pounds into a 300-mile orbit. The higher payload capacity of these vehicles makes it possible to install more scientific instrumentation in each payload for making more measurements simultaneously, thus increasing the value of each set of data.

Your instrumentation is directly relative to the amount of thrust you have, is it not?

Dr. SILVERSTEIN. Yes, sir.

PROGRAM COSTS

Mr. THOMAS. Put the table on page 153 in the record, Mr. Reporter.

(The matter referred to follows:)

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Advanced technical development:			
Scientific and technical studies	$1,155,114	$1,500,000	$2,000,000
Development of advanced instrumentation	1,520,000	3,061,000	6,000,000
Flight research program:			
JUNO II vehicles	8,540,000	5,100,000	
THOR-ABLE vehicle	2,120,000	727,000	
ATLAS-AGENA B vehicles			3,000,000
THOR-AGENA B vehicles			3,000,000
Scout vehicles			3,500,000
Satellite vehicles	7,970,000	13,425,000	24,200,000
Total	21,305,114	23,813,000	41,700,000

Mr. THOMAS. This is a summary breakdown of your research program. Scientific studies, $2 million, development of advance instrumentation, $6 million. This is your technical development. Your flight research program includes the JUNO vehicles. You do not have any money allocated for them, nor do you for the THOR-ABLE. The ATLAS-AGENA B vehicles require $3 million, THOR-AGENA B, $3 million; SCOUT, $3.5 million, and the satellite payloads, $24,200,000.

SATELLITE PAYLOADS

Let us see your justification for the $24.2 million.

Dr. DRYDEN. There is a breakdown of these figures in the succeeding pages, starting on 153–18.

Mr. THOMAS (reading):

Funding for the payloads can be considered as being almost entirely directed to the support of the specific flights.

Put page 153–15 and 153–16 in the record. I don't think 17 adds too much. Let us put the breakdown on 153–18 through 153–24 in the record.

(The pages referred to follow:)

SATELLITE PAYLOADS

Funding for payloads can be considered as being almost entirely directed to the support of specific flights. However, in the fiscal year 1959, some funding was devoted to the provision of general payload instrumentation. With this funding, the procurement of instruments which could be made available on a relatively routine basis to the general run of satellite payloads was started. It has already been found that if satellites intended for research in a specific scientific discipline weight as much as 100 pounds or more, it is generally possible to introduce one or two additional lightweight instruments to supplement the original project objectives. In these cases, such supplementary instrumentation is extremely valuable as it permits correlations in two or more associated research areas. This add-on process can appreciably increase the statistical value of the data being collected by putting similar detecting systems into a sequence of satellites so as to verify the initial data and then obtain an indication of the time and space variations which occur. Consequently, instrumentation efforts on magnetometers, micrometeorite detectors, gamma ray detectors,

radiation detectors, and the like is continuously being supported. In this way a number of payload instrument equipments for routine use are made available. Some of the general support is continued in fiscal years 1960 and 1961 programing, while other areas have grown into major projects and are covered in specific payloads detailed in the tabulation.

Funding of Explorer VI, the "Paddlewheel" satellite, and Explorer VII will be completed in the fiscal year 1960. Explorer VII shows no fiscal year 1959 funding in the tabulation because the project was initially established by ARPA and was supported through the fiscal year 1959 by the original funding.

Payload instrumentation to measure the penetration and damage hazards of micrometeorites is being prepared for the third developmental SCOUT vehicle as a part of the fiscal year 1960 program.

Several satellite payloads were initiated in the fiscal year 1959. These were: The ionosphere beacon satellite; the ionosphere direct-measurements satellite; the radiation belt satellite; the atmospheric structure satellite; the advanced radiation belt satellite; and the solar observatory satellite. In each case, the funding programed in the tabulation reflects the leadtime required to design, fabricate, and launch a payload.

Funding for data acquisition and processing is introduced for those projects which require special handling of a type which cannot be supplied by the established network. Special equipment needed for a single payload, is included in the payload funding where appropriate.

Funding has been initiated in the fiscal year 1960 for the geodetic satellite, the topside sounder, the gamma ray astronomy satellite, the solar geophysical satellite, the orbiting geophysical observator, and the orbiting astronomical observatory. For all of these, program costs in the fiscal year 1961 are indicated and there will be additional charges in 1962 to complete the flight programs.

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
General payload instrumentation:			
Cosmic-ray detectors	$75,000		
Magnetometer testers (mobile equipment)	50,000		
Magnetometer tester (fixed)	160,000		
Magnetically shielded enclosure	100,000		
Microammeters	90,000		
Optical design and ultraviolet detectors	50,000		
Photomultiplier (ultraviolet) ruggedization	195,000		
Solar pointing controls	80,000		
Solar ultraviolet detector elements	120,000		
Tracking beacons	90,000		
Rubidium vapor magnetometers	170,000	$60,000	
Spectrophotometer assemblies	96,000	100,000	
Gamma-ray detectors	32,000	60,000	$100,000
Micrometeorite detectors	160,000	160,000	160,000
Air density instrumentation		99,000	
Explorer VI:			
Payload effort and field support	5,000,000	1,290,000	
Data reduction		363,000	
Scout micrometeorite payload		150,000	
Explorer VII:			
Payload effort and field support		2,000,000	
Data acquisition, Pacific stations		50,000	
Data processing		300,000	
Ionosphere beacon satellite: Payload system design and fabrication	557,000	300,000	270,000
Ionosphere direct-measurements satellite:			
Instrumentation	220,000	292,000	56,000
Structures, including antennas		585,000	150,000
Data processing			50,000
Advanced radiation belt satellite:			
Cosmic-ray detectors	30,000	60,000	60,000
Solid-state radiation detectors	15,000	95,000	30,000
Magnetometers	15,000	95,000	50,000
Pulse-height analyzers	30,000	165,000	60,000
Signal processing circuitry		20,000	25,000
Telemetry	10,000	40,000	35,000
Power supplies	20,000	63,000	20,000
Structures, including antennas		144,000	192,000
Testing services		50,000	140,000
Payload for test on Scout	60,000	110,000	
Data processing			100,000

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Atmospheric structure satellite:			
Mass spectrometers and pressure gages	$60,000	$300,000	$100,000
Signal processing circuitry	10,000	40,000	80,000
Telemetry	20,000	80,000	100,000
Power supplies	10,000	40,000	80,000
Structures, including antennas	45,000	174,000	295,000
Testing services		50,000	110,000
Radiation-belt satellite:			
Design and construction at AOMC	150,000	700,000	
Analysis of orientation and temperature		75,000	
Data processing		50,000	100,000
Solar observatory satellite:			
X-ray spectrographs	30,000	250,000	
Photomultiplier detectors		50,000	
Gamma-ray detectors		40,000	
Signal processing circuitry		20,000	
Telemetry	10,000	80,000	
Power supplies		70,000	
Structures, including antennas and pointing controls	90,000	679,000	
Testing services	10,000	100,000	
Pointing controls for rocket test	20,000	80,000	
Spectrographs for rocket test	30,000	100,000	
Payload fabrication for rocket test	60,000	10,000	
Data acquisition equipment			200,000
Data processing			200,000
Data analysis			150,000
Geodetic satellite:			
Flashing light system		250,000	100,000
Timing units		40,000	40,000
Earth sensors		30,000	20,000
Tracking beacons		25,000	50,000
Ranging transponder		35,000	100,000
Telemetry		35,000	50,000
Power supplies		40,000	80,000
Antenna systems development		40,000	30,000
Prototype structures		200,000	150,000
Testing services		50,000	100,000
Data acquisition equipment		50,000	350,000
Data processing equipment			150,000
Topside sounder:			
Project coordination		34,000	87,000
Payload design and fabrication		270,000	725,000
Testing services			100,000
Gamma-ray astronomy satellite:			
Design, fabrication, and test at AOMC		690,000	470,000
Gamma-ray instrumentation		225,000	
Tape recorder for data storage		22,000	
Data processing			50,000
Polar geophysical satellite:			
Scientific instruments		90,000	350,000
Payload structural prototype		60,000	250,000
Prototype dynamic tests		40,000	160,000
Signal processing circuitry		20,000	80,000
Telemetry		20,000	200,000
Antenna systems design		20,000	80,000
Power supplies		10,000	70,000
Flight structures		80,000	400,000
Testing services		10,000	100,000
Orbiting geophysical observatory:			
Scientific instruments		140,000	350,000
Payload structural prototype		60,000	250,000
Signal processing circuitry		20,000	80,000
Telemetry		20,000	200,000
Antenna systems design		20,000	80,000
Power supplies		10,000	70,000
Flight structures		80,000	400,000
Testing services		10,000	150,000
Solar geophysical satellite:			
Geophysical sensors		150,000	200,000
Solar radiation detectors		100,000	150,000
X-ray spectrographs		80,000	100,000
Signal processing circuitry		20,000	80,000
Telemetry		20,000	200,000
Antenna systems design		20,000	60,000
Power supplies		10,000	100,000
Flight and prototype structures		80,000	650,000
Testing services		10,000	200,000
Pointing controls for rocket test		40,000	60,000
Spectrograph for rocket test		50,000	80,000
Payload fabrication for rocket test		20,000	50,000

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Orbiting astronomical observatory: Instrumentation:			
Photoemissive detectors		$125,000	$200,000
Photomultiplier detectors		60,000	120,000
Filters		60,000	80,000
Crystalline optical components		40,000	80,000
Image intensifiers		80,000	175,000
Optical system design		75,000	250,000
Ion chambers			75,000
Solid-state detectors			45,000
Spectroscopic gratings			30,000
Construction of optics			200,000
Optical test equipment			190,000
Stabilization, structure, and control:			
Basic structure			450,000
Attitude sensors			350,000
Servostabilizers			500,000
Coarse pointing unit			250,000
Fine pointing unit			400,000
Command system			200,000
Electronic processing circuitry			180,000
Telemetry			200,000
Power supplies			200,000
Antenna systems design			100,000
Testing services			200,000
Ground control equipment			250,000
Checkout and test sets			200,000
Four Scout payloads:			
Scientific instruments			1,300,000
Signal processing circuitry			400,000
Telemetry			600,000
Power supplies			600,000
Antenna design			320,000
Structural design and fabrication			1,400,000
Testing services			800,000
Three Scout payloads—International program:			
Signal processing circuitry			300,000
Telemetry			450,000
Power supplies			450,000
Antenna design			290,000
Structural design and fabrication			1,000,000
Testing services			600,000
Total	$7,970,000	13,425,000	24,200,000

Mr. THOMAS. Where are these developed? The doctor was telling us at Goddard a good part of it is developed in the laboratory.

Dr. DRYDEN. Some in Goddard Laboratory, much of it by contract.

Mr. THOMAS. From industry?

Dr. DRYDEN. Yes.

Mr. THOMAS. How does he arrive at this tremendous figure of $24,200,000 out of 50, 75, or 100 items ranging up to $1.4 million? Here is one for $300,000.

Dr. SILVERSTEIN. Many of these items are continuations of work underway. Others are based on our past history in the development of objects.

Mr. THOMAS. How much money did you have for this same purpose last year?

Dr. DRYDEN. $13,425,000 for 1960.

Mr. THOMAS. Where is that table?

Mr. HORNER. 153–24.

Mr. THOMAS. How much of this has been obligated?

Mr. ULMER. I have the sum of all 1960 obligations against the total 1960 scientific satellite program, Mr. Thomas. It is $14.8 million.

Mr. THOMAS. You had $21 million for payloads for the 2 years. Can you break it down? If you are going to use an accumulative figure, what was it for the first of January or some recent period?

Dr. DRYDEN. Mr. Ulmer's figure is the sum of the several items that make up the scientific satellites program, not just the payloads.

Mr. THOMAS. Are you using a cumulative figure for 1959 and 1960?

Mr. ULMER. I gave you the 1960 figure, Mr. Chairman. The 1959 allotment was $21.3 million and is entirely obligated.

Mr. THOMAS. You did not have that much in 1959.

Mr. ULMER. I am talking about the cumulative figure for the entire scientific satellites program.

Mr. THOMAS. What about your 1960 figure?

Mr. ULMER. Of the 1960 figure of $23.8 million we have obligated $14.8 million, and we have committed an additional $2 million.

Mr. THOMAS. What will be your carryover into 1961?

These are no year funds, I realize that.

Mr. ULMER. They are. This would be a pure guess, Mr. Thomas. I do not know how much we would carry over.

Dr. SILVERSTEIN. Let me guess at that, because I watch this program closely. I do not think there will be any carryover in this program. We will be very close on it.

Mr. THOMAS. I thought you would say that, Doctor.

Dr. SILVERSTEIN. I am quite up to date on this one, and I know some of the problems we have right now in trying to get through the year.

Mr. THOMAS. I should not have let you say anything because I knew what that answer was going to be.

Mr. ULMER. I think our 1959 experience bears that out. This is one that has been very close.

LUNAR AND PLANETARY EXPLORATION

Mr. THOMAS. Let us turn to your request with reference to lunar and planetary exploration wherein you are requesting $45 million for fiscal year 1961, as against $49 million in 1960 and $31,882,607 in 1959. Your justifications state that your objectives are as follows:

To acquire fundamental physical and chemical information on the Moon and planets; to investigate space phenomena and their variations over the range of lunar and interplanetary distances; to explore the surface and nearby environment of the Moon and to measure and describe in detail its characteristics, for example, the surface composition, radioactivity, and structural features——

As the nearest major body in the solar system, how far is it away?

Mr. HORNER. 240,000 miles.

Mr. THOMAS. Your justifications continue:

As our nearest major body in the solar system, basically unchanged for billions of years, the Moon itself offers unique potentialities for better understanding of historic and contemporary phenomena of the solar system—

We know all about that. If it has not been changed for billions of years, why not leave it alone?

Dr. SILVERSTEIN. The fact that it has not been changed can give us some understanding, perhaps, of what our Earth was that many years ago and, maybe, we will get at some of these origins.

Mr. THOMAS. Are we going to change it much now?

Dr. SILVERSTEIN. I hope we will not change it too much, but we might learn something from it.

Mr. THOMAS. Your justifications further state:

Until now, progress along these lines has been subject to the limitations imposed by remote observations and indirect measurements.

Do you think we will be able to do away with that big dish over in West Virginia now?

Dr. SILVERSTEIN. I think we are going to be able to use it quite well in some of our programs.

JUSTIFICATION OF THE ESTIMATES

Mr. THOMAS. We shall insert at this point in the record pages 154, 155 and 156, as well as the table which appears on page 157 of the justifications.

(The pages referred to follow:)

LUNAR AND PLANETARY EXPLORATION

Fiscal year 1959	$31,882,607
Fiscal year 1960	49,000,000
Fiscal year 1961	45,000,000

1. Objectives

To acquire fundamental physical and chemical information on the Moon and planets; to investigate space phenomena and their variations over the range of lunar and interplanetary distances; to explore the surface and nearby environment of the Moon and to measure and describe in detail its characteristics, for example, the surface composition, radioactivity and structural features, and the magnetic and gravitational fields; to investigate the constituents, processes, and characteristics of the interplanetary regions so as to understand how and why they vary with time and location within the solar system; to extend these investigations to the detailed study and exploration of the planets; to develop improved means and techniques for the coduct of lunar, interplanetary and planetary investigations and explorations.

2. Justification

As our nearest major body in the solar system, basically unchanged for billions of years, the Moon itself offers unique potentialities for better understanding of historic and contemporary phenomena of the solar system and for clarification of basic physical, chemical, and biological concepts that are fundamental to modern science. It can be hoped that the Moon will provide the first answers that will unlock the secrets of the origin and evolution of the solar system. Until now, progress along these lines has been subject to the limitations imposed by remote observations and indirect measurements. The understanding which can be gained from direct measurements and observations will be far greater. Space flight vehicles now offer research capabilities for overcoming many of these limitations.

In particular, it will be possible to utilize appropriate instrumentation to determine, by direct measurement, lunar, planetary, and interplanetary characteristics, and thus provide a wealth of fundamental information on the nature, magnitude, distribution, and variations of the electromagnetic radiations, energetic particles, electric and magnetic fields, cosmic dust particles, lunar, planetary, and solar atmospheres which are continuously interacting within the solar system. These interactions are already known to markedly influence the earth's atmosphere and fields, and a knowledge of their mechanisms will clarify our understanding of terrestrial phenomena.

The advancement of scientific knowledge obtained from early lunar explorations and space probes and the experience that will be gained from the operation of space flight systems hundreds of thousands of miles from earth, will provide the basis for the appropriate design of instrumented spacecraft which will eventually explore the planets and deep space.

3. Program phasing

During the fiscal year 1959, lunar and cislunar space probes permitted evaluation of initial problems associated with the placing of vehicles into lunar trajectories and provided preliminary information on environmental characteristics

of cislunar space. Work was initiated on advanced instrumentation and measurement techniques, including, for example, a lunar seismograph system, a plasma probe, a magnetometer to be used in lunar probe flights, and instruments for measuring lunar radioactivity. PIONEER IV, which was initiated by ARPA and transferred to NASA, was placed in permanent orbit around the sun. The instrumentation in PIONEER IV furnished valuable new data on the radiation belt and its extent into space, showing for one thing that the outermost portions of the radiation belt vary quite markedly with activity in the sun. Funding was initiated for an ATLAS-ABLE vehicle to be used in placing a scientific payload in orbit about the moon, and a THOR-ABLE vehicle to launch a deep space probe. Development, construction, and testing of payloads for both lunar and deep space probe missions were initiated.

Work is being started during the fiscal year 1960 on the development of instrumentation and vehicle systems with improved capabilities for investigating cislunar space and beyond. The development of advanced instrumentation started in the fiscal 1959 is continuing. A lunar orbiter payload was designed and constructed for the ATLAS-ABLE vehicle for which funding was started in the fiscal year 1959. A preflight failure of the vehicle made it necessary to provide a second booster system. This launch attempt was unsuccessful. Additional lunar orbiters and probes are planned for launching in the fiscal year 1960 and in the fiscal year 1961. Work will also be started on planetary probe payloads. The THOR-ABLE vehicle funded in the fiscal year 1959 will be used to launch a deep space probe; its payload is being completed during the fiscal year 1960.

The funds requested under this program for the fiscal year 1961 will provide for the design and development of measurement techniques, scientific instruments, and spacecraft for use in lunar and planetary investigations. Work will continue on the construction and testing of advanced systems to observe, study, explore, and investigate the lunar environment, surface, and interior. Studies and preliminary research and development projects will be extended in the fiscal year 1961 to acquire needed technology for spacecraft with a capability for precise circumlunar orbits and instrumented soft landings. Terminal orientation devices and landing controls and propulsion units for spacecraft will be inevstigated. Design and construction of prototype instrumentation will be initiated for a lunar seismograph and gravimeter system, advanced penetrometers, thermistor probes, and fluorescence spectroscopes.

Beginning in the fiscal year 1961 the ATLAS-AGENA will be utilized for launching of lunar probe spacecraft. Construction and environmental testing will start on payloads for lunar impact missions with the objective of providing knowledge necessary for the proper design of soft lunar landing vehicles. These payloads will be instrumented to transmit data on the surface characteristics of the moon.

Typical projects included in the advanced development program for lunar, planetary, and interplanetary instrumentation will be studies of infrared sensors and penetrometers for the investigation of lunar and planetary surface structures; improvement of plasma probes, geiger and scintillation counters for measurements of the interplanetary medium; improvement of magnetometers to be used in particle flux-magnetic field correlations; beta and gamma ray detectors and spectral analyzers for studies of lunar surface radioactivty; and improvements of television-type image transmission equipment for lunar studies.

An interplanetary space probe will be launched during the fiscal year 1961 by means of a DELTA vehicle funded under the DELTA development program. Design and development effort on the payloads for use in an initial pair of planetary probes will be carried forward with the expectation that ATLAS-AGENAS will be used as booster vehicles.

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Advanced technical development	$8,102,607	$5,223,000	$9,000,000
Flight research program:			
Completion of PIONEER IV vehicle system operations	2,140,000		
THOR-ABLE vehicle	2,843,000		
ATLAS-ABLE vehicles	4,097,000	3,446,000	
ATLAS-AGENA vehicles	3,500,000	7,360,000	9,500,000
Design, development: fabrication, and launch of spacecraft and payloads	11,200,000	32,971,000	26,500,000
Total	31,882,607	49,000,000	45,000,000

ADVANCED TECHNICAL DEVELOPMENT

Mr. THOMAS. You have an item under "Program costs" entitled "Advanced Technical Development." How do you arrive at a figure of $9 million for that item? For "Design, development, fabrication, and launch of spacecraft and payloads" you have the sum of $26.5 million.

How do you arrive at these tremendous figures?

Mr. ULMER. They are made up, Mr. Chairman, of dozens of individual items, and the listing starts on page 157–7. This is a listing of the individual developments which go to make up the $9 million item.

Mr. THOMAS. How do you spend this money? Where is this money spent?

Dr. SILVERSTEIN. A large part of the $26 million will be spent under contract.

Mr. THOMAS. What is the nature of your expenditures?

In your "Design, development, fabrication, and launch of spacecraft and payloads," this goes into your engine development, your power development, your payloads, and everything else?

Dr. SILVERSTEIN. Yes, sir. The breakdown of that into the advanced technical development for vehicles and the payloads are shown on page 157, and then the more detailed breakdown of the items included within the spacecraft are shown starting on page 157–6.

Mr. THOMAS. We shall insert into the record at this point the tables which appear on pages 157–6, 157–7, and 157–8, as well as the top part of 157–9.

(The pages referred to follow:)

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Cosmic ray instrumentation, development	$74,951		
Lunar data-recording system, development	75,000		
Study of lunar soft-landing systems	150,000		
Lunar radioactivity instrument development	150,000		
Coherent radar explorations	126,000		
Radiation instruments, development	150,000		
Studies of radiation belt properties	311,420		
Studies of primary cosmic radiation	300,280		
Magnetic calibrations	27,000		
Coincidence telescope, development	63,140		
Special computations at NBS	58,000		
Television for space vehicles, development	300,000		
Study of deep space system requirements	50,000		
Supporting research on lunar mission problems	90,000		
Lunar and planetary exploration studies	1,300,000		
Development and construction of lunar orbiter and space probe payloads	4,522,616		

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Plasma instrumentation, development	$97,200	$75,000	
Lunar seismograph system, development, CIT	125,000	150,000	$90,000
Advanced lunar seismograph system, development, Columbia University	125,000	150,000	250,000
Lunar photogrammetry, development	15,000	72,370	90,000
Spectral lamps, development		30,000	
Lunar map studies		67,630	
Instruments to measure atmospheric pressures between Earth and Moon, development		50,000	
Study of lunar surface characteristics		115,000	
Electromagnetic investigation of lunar surface properties		50,000	
Space radar equipment, development		50,000	
Micrometeorite simulation studies		50,000	
Ionosphere of JUPITER, studies		50,000	
Detection of planetary microorganisms, studies		4,500	
Ultraviolet sensors, development		215,500	
Photodiode system for planetary surface light, development		368,000	
Lunar photographic system, development		500,000	
Cosmic ray and magnetometer, development		450,000	
Development of impact-proof payload components		105,000	
Spacecraft sequence timer, development		445,000	
Development of lunar retropackage		1,500,000	
Sterilization of space payloads, study		30,000	80,000
Lunar penetrometer, development		80,000	125,000
Mass spectrometer, development		75,000	105,000
Lunar surface gravity meter system, development		55,000	155,000
X-ray fluorescent spectrometer, development		135,000	195,000
Surface sampling complex X-ray development		100,000	150,000
Heavy cosmic ray detectors		75,000	100,000
Interplanetary gas and dust, studies		50,000	75,000
Gamma ray spectrometer, development		20,000	150,000
Infrared photography of moon		105,000	125,000
Photogrammetric interpretation of lunar composition, study			110,000
Instruments for measuring lunar atmospheric characteristics, development			220,000
Solar corpuscular detector, development			100,000
Photoconductive particle detector, development			400,000
Rubidium vapor magnetometer, development			100,000
Coincidence detectors, development			400,000
Ion chamber, development			100,000
Lyman alpha scanner, development			200,000
Micrometeorite detector, development			100,000
Vehicle electrostatic charge, development			275,000
Environmental testing of instrument assemblies			325,000
Advanced vidicon, development			750,000
Skin temperature sensors, development			115,000
Ion trap, development			80,000
Procurement of 2 service-test instruments:			
Vidicons			780,000
Gamma ray spectrometers			200,000
Seismographs			260,000
Penetrometers			130,000
Temperature sensors			80,000
Ion traps			80,000
Magnetic and electric field instruments, VENUS, development			125,000
Energetic particle instruments, VENUS, development			275,000
Atmospheric instruments for VENUS, development			100,000
Ionospheric instruments for VENUS, development			100,000
Spectroscopic photometer, development			450,000
Development of television for Mars probe			400,000
Magnetic and electric field instruments, Mars, development			100,000
Spectroscope, Mars, development			150,000
Advanced magnetometer, development			30,000
Surface thermal measuring instruments, development			35,000
Advanced plasma probe, development			55,000
Remote-controlled TV, development			185,000
Advanced instruments for solar probes:			
High resolution spectroscope			200,000
Colomagraphic equipment			100,000
Temperature and pressure devices			100,000
Mass spectrometer			100,000
Total	8,102,607	5,223,000	9,000,000

Mr. THOMAS. These are all round figures, and figures are just figures. There is no explanation. I am wondering where you get these figures.

Dr. SILVERSTEIN. For example, Dr. Pickering's group at the Jet Propulsion Laboratory has been looking at these figures. These esti-

mates have been made by them and it is a breakdown of the job that they have as an assignment; that is, the lunar and interplanetary spacecraft, and they are experienced in the cost of some of these types of developments, based on the work they have done in the past.

Mr. THOMAS. Of course, these are brandnew operations and there is no prototype development on it. It is bound to be a "guess" figure. Your guess may be high and it could be low.

Dr. SILVERSTEIN. Our experience thus far has been that we have been guessing low where we have had to guess.

Mr. THOMAS. Of course, when you go to changing your program around—and you are bound to change your program quite often—if there is any miscalculation, it will come within that field.

Dr. SILVERSTEIN. It will come generally there but generally it comes about because we are in a field of future development and we do not quite know the problems that we are going to run into. This is generally more costly than we anticipate, because even in cases where you have a fairly good idea of what you are going to do, you quite often run into a snag which makes it more costly.

USE OF THE TITAN

Mr. BOLAND. I notice in looking at the launching vehicles, Dr. Silverstein, that you are using the ATLAS-ABLE-AGENA.

Is there any use at all for the TITAN?

Have you considered using it at all?

Dr. SILVERSTEIN. We have no spacecraft that are currently based on the TITAN as a first-stage booster. We have used the ATLAS because it came into use in the military service area and it has acquired a long history of testing and development. Our probability of successful flight, using a vehicle such as the ATLAS which had had up to that time 22 successful flights in a row, makes it possible for us to add one element of reliability into our system that we were very anxious to have.

The TITAN has not had this background of flights to establish its reliability.

Mr. HORNER. I do not know if I can add very much, but I think there is a possibility at sometime in the future that we might fire a TITAN first stage, tailored to our requirements, but at the present time all of the effort in the TITAN program is to make a reliable weapons system. This is very important to the Department of Defense and they would not want us to interpose at this time a requirement for a space vehicle nor would we want to because of the reliability considerations which Dr. Silverstein mentioned.

Mr. BOLAND. Thank you.

METEOROLOGY

Mr. THOMAS. Gentlemen, let us take a look at your weather activities in meteorology.

Your justifications state as follows:

To establish a meteorological satellite capability for worldwide coverage and for providing observations of atmospheric elements required by the meteorologist in order to understand atmospheric processes and predict the weather. These

elements include cloud cover, storm location, precipitation, temperature, wind direction, heat balance, water vapor, and other constituents.

Our friend, Dr. Revelle, thinks you are going to have to go to the bottom of the ocean before you get the complete answer and that you are not going to get it all in the higher altitudes.

Your justifications further state as follows:

The benefits to be derived from these improved capabilities in meteorology include convenience in planning personal activities, protection of life and property from weather disasters; safeguarding transportation; crop planning, control, and protection, industrial planning of weather-dependent products, outdoor enterprises, and heating and cooling loads—

and so forth.

You are a little bit ambitious here, are you not?

How will you spend this $20.7 million?

PROGRAM COSTS

Insert at this point in the record page 160 of the justifications.

(The page referred to follows:)

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Advanced technical development:			
Atmosphere, radiation, and data systems research	$158,550	$1,250,000	$1,400,000
Development of advanced instrumentation	11,000	3,099,000	4,400,000
Flight research program:			
Payloads	818,000	3,581,000	9,200,000
Booster vehicles			5,700,000
Total	987,550	7,930,000	20,700,000

Mr. THOMAS. For atmosphere, radiation, and data systems research you are requesting the sum of $1.4 million and for the development of advanced instrumentation you are requesting the sum of $4.4 million.

In your flight research program for payloads you are requesting the sum of $9.2 million and for booster vehicles you are requesting the sum of $5.7 million.

Do you buy your boosters from the Air Force?

Dr. DRYDEN. Yes.

Dr. SILVERSTEIN. This will be a THOR–AGENA vehicle.

Mr. THOMAS. What is the altitude? I believe you say you are going up to an altitude of about 320 miles.

Dr. SILVERSTEIN. About 600 miles for the NIMBUS and 380 miles for the TIROS.

Mr. THOMAS. What are your payloads which come to $4.4 million?

Dr. SILVERSTEIN. That breakdown is shown on pages 160–7 and 160–8.

Mr. THOMAS. Do you break down your figure of $4.4 million?

These figures do not mean anything the way you set them out. It looks as if you just pulled them out of the atmosphere.

We shall insert in the record pages 160–5 through 160–8.

(The pages referred to follow:)

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Studies of advanced radiation methods	$11,000	$100,000	$100,000
Tape recorder for TIROS radiation experiments		154,000	
Electrostatic tape recording camera		350,000	
Advanced vidicon camera systems		500,000	
Radiation scanning heads and detectors:			
Scanning systems studies		100,000	100,000
Uncooled detectors for region beyond 6.3m		80,000	150,000
Dielectric and related bolometer studies		100,000	100,000
Detector cooling techniques		50,000	50,000
Electronic and mechanical instrumentation:			
2-watt, 240-megacycle wide-band transmitter		50,000	
Special 5-channel telemetry		30,000	
Control electronics for special tape recorder		25,000	
Clocks, programer, controls and switching system		120,000	
Tape recorders		25,000	100,000
Secure digital command system		100,000	100,000
5-watt, 1700-megacycle, wide-band transmitter		50,000	100,000
Special telemetry beacon and switch		50,000	50,000
VHF, UHF, and microwave antenna systems		50,000	50,000
Infrared radiation satellite systems:			
Special supplies and materials		560,000	410,000
Support services		125,000	340,000
Attitude control components and system		380,000	1,500,000
Satellite-borne radar		100,000	400,000
Electronic components:			
Constant beta, low-noise transistor			70,000
1000-megacycle, 1-watt transistor			100,000
High-resolution electron gun			80,000
Far infrared imaging device			100,000
Image orthicon system			300,000
Advanced data transmission study			100,000
Spectrometer			100,000
Total	11,000	3,099,000	4,400,000

PAYLOADS

When the meteorological satellite program, TIROS, was transferred to NASA from the Department of Defense in April 1959, some $7,977,000 had been provided by ARPA for payload development either directly to the contractor or through NASA. The funding by NASA since the transfer has been for completing the development and production of five basic payloads in the TIROS series, the modification of equipment at read-out stations, special support operations involved at these stations and the analysis of the data acquired by the satellite.

With the availability of data from TIROS I and TIROS II, the major effort of the Meteorological Satellite Section of the U.S. Weather Bureau will turn to the problem of satellite data analysis and interpretation. The scanning radiation data acquired by TIROS II will be converted from analog to digital information and processed for Weather Bureau use. The data will also be analyzed for application to future satellite-borne radiation measurements.

The follow-on satellite to the TIROS series will be the NIMBUS satellite. One of the basic problems in NIMBUS is the development of a suitable spaceframe whose structure and components are compatible with the structure and components of the terminal stage of the launch vehicle. In the fiscal year 1960, the basic hardware and test equipment will be acquired for the spaceframe development. NIMBUS is a large and complex satellite with a number of meteorological sensory systems, a stabilization system, and a power supply system. The selected contractor for the NIMBUS satellite payload development and integration will provide through approved and appropriate subcontractors the structures, television subsystem components, the electrostatic tape recorders, the radiation measurement equipment, the electronic controls (timers, transmitters, receivers, beacons, tape recorders) and other mechanical parts that will constitute the satellite. In addition, there will be a single contractual effort for the development and production of the solar cell power supply intended for the satellite.

The proof of the reliability of a finished satellite is the most difficult and most critical phase of the satellite development effort. The testing program will include vibration, acceleration, vacuum-thermal and life testing of each of the seven basic NIMBUSES developed. A 3-month life test program will be carried out for each of the five flight models.

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
TIROS I:			
Completion of payload development and construction	$278,000	$1,555,000	
Modification of equipment and station operation for data acquisition:			
Deal, N.J.	260,000		
Kaena Point, Hawaii	280,000	155,000	
Atlantic Missile Range		30,000	
Quick demodulation equipment		28,000	
Data analysis		300,000	
TIROS II:			
Payload modification		400,000	
Station operation for data acquisition		113,000	
Prelaunch payload operations			$500,000
Data analysis			800,000
Special radiation analyses			100,000
Analog to digital data conversion			200,000
NIMBUS:			
Terminal stage structure and hardware		350,000	
Stabilization components		150,000	
Stabilization subsystem structure construction		250,000	
Special test equipment for stabilization system		250,000	
Payload development and construction			5,000,000
Environmental testing of payload			2,000,000
Payload power supply, development and construction			600,000
Total	818,000	3,581,000	9,200,000

BOOSTER VEHICLES

The TIROS I vehicle (THOR-ABLE) was funded by the Department of Defense during the period of inception of the program in that agency. The TIROS II vehicle (THOR-DELTA) was funded under the DELTA vehicle development program. Consequently, no booster vehicle costs are indicated in the meteorological satellite program in the fiscal years 1959 and 1960.

The funding during the fiscal year 1961 will partially cover the cost of two THOR-AGENA B launch vehicles.

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Procurement of 4 THOR-AGENA B launch vehicles (partial funding)			$5,700,000

Mr. THOMAS. These figures do not mean anything. It is just a straight tabulation with no indication of how you arrive at them.

Will this be done by contract?

Dr. SILVERSTEIN. Yes, sir.

Mr. THOMAS. What part of this $20 million will be spent in the laboratory at Goddard?

Dr. SILVERSTEIN. A large amount of this will be by contract. A very small amount will be spent at the laboratory.

BOOSTERS IN PROGRAM

Mr. THOMAS. Will you contract with the Air Force to get your boosters? How many will you have?

Dr. SILVERSTEIN. I think we are making partial payment on two boosters in this program. There will be four boosters.

Mr. THOMAS. What is the figure for your boosters?

Dr. DRYDEN. $5.7 million.

Mr. THOMAS. What is the unit cost? Is it coming down any as you buy more?

Dr. SILVERSTEIN. That is an error. On page 160–8 that 4 should be 2. At the bottom of the page, where reference is made to the procurement of 4 THOR-AGENA launch vehicles, that should be 2.

Mr. THOMAS. Rather than four?

Dr. SILVERSTEIN. At that point, yes.

Mr. THOMAS. That is page 160–8?

Dr. SILVERSTEIN. Yes, sir.

Mr. THOMAS. How much are you reducing it, or are you increasing it?

Dr. SILVERSTEIN. We are not increasing the number. This was a typographical error. On the line above there it states the funding during fiscal 1961 will partially cover the cost of two THOR–AGENA launch vehicles, and when it was copied on the lines below, it was typed "4."

Mr. THOMAS. What does the unit cost?

Dr. SILVERSTEIN. The unit cost of the THOR-AGENA–B is estimated currently at about $3.8 million.

Mr. THOMAS. $3.8 million?

Dr. SILVERSTEIN. Yes, sir.

Mr. THOMAS. Has the unit cost come down? You bought several of these from the Air Force, did you not?

Dr. SILVERSTEIN. We have not bought these yet.

Dr. DRYDEN. This is a new vehicle.

Dr. SILVERSTEIN. It is just coming into use in the Air Force now.

Mr. THOMAS. What is the altitude of this one?

Dr. SILVERSTEIN. This vehicle will go to an altitude of about 660 miles.

Mr. THOMAS. How much payload will it carry? Is that figure 250 pounds or 300 pounds?

Dr. SILVERSTEIN. This will have a payload of about 600 pounds.

Mr. THOMAS. At that relatively low altitude?

Dr. SILVERSTEIN. Yes, sir.

Mr. THOMAS. What will your instruments cost on one of these?

Dr. SILVERSTEIN. The instrumentation breakdown that we have shown on these pages——

Mr. THOMAS. No; on one unit?

Dr. SILVERSTEIN. It is estimated, I think, for one of these units that the instrumentation will cost about $4.5 million.

Mr. THOMAS. Well, you have about $8.2 million total cost for one payload of 600 pounds up to 300 or 400 miles?

Dr. SILVERSTEIN. That is about what they average.

NIMBUS PROGRAM

Mr. THOMAS. What specific information do you hope to gain by that shot?

Dr. SILVERSTEIN. This is the NIMBUS program which is the follow-on of the TIROS. We will have aboard this particular flight not only the TV cameras that we are trying in TIROS, but we will have in addition the radiation measuring equipment and infrared scanning equipment to get the heat balance between the sun and the earth and from the earth out into space. These satellites will be aimed at the earth directly because they are not spinning and they can take a picture of the whole surface.

Mr. THOMAS. What diversity of payload do you use? Say, for instance, you have 10 different gadgets in your average payload. Are they repeaters or do you have different instrumentation and make different tests; or do you try to get a different reading on the same instrument at a different altitude; or just what do you gain by each test that you did not gain before?

Dr. SILVERSTEIN. Our history here will be one in the next several years of a continual improvement in the quality of the instrumentation we carry. We have learned our business and gradually developed this type of satellite up to operational capability where it can be used, say, in a routine operation to get weather information.

This is a standard development procedure where you start with certain equipment and then gradually develop it by increasing its life and its reliability, its scanning capability, and its ability to transmit information. All of these things will be improved progressively.

COMMUNICATIONS

Mr. THOMAS. We shall insert at this point in the record pages 161 through 163 of the justifications.

(The pages referred to follow:)

COMMUNICATIONS

Fiscal year 1959	$3,574,806
Fiscal year 1960	3,170,000
Fiscal year 1961	5,600,000

1. Objectives

To develop communications satellites and operating techniques for use in a worldwide communications system using satellites as relay stations for ground-to-ground, ground-to-satellite, and satellite-to-ground transmission of messages, data, voice, and television; to develop communications systems for the transmission of scientific data from deep space probes to earth and of commands from earth to deep space probes; and to conduct studies of the application of active relay satellites to civilian and commercial communications.

2. Justification

Long-range communications in the form of telephone, telegraph, and television networks are now accomplished by means of landlines, cables, long- and short-wave radio, and microwave relay stations. The total bandwidth of landlines, cables, and low-frequency radio is limited. Shortwave radio bands are crowded and are unreliable because of atmosphere interference and ionospheric irregularity. Ultra-short-wave or microwave radio is usually limited to line-of-sight range; long-distance communication at these frequencies is commonly achieved by means of repeater stations.

Satellites offer the possibility of worldwide communications by ultra-short-wave or microwave radio because the line-of-sight range at satellite altitudes is very large. The bandwidth or channel capabilities at these wavelengths is sufficient for television and most other foreseeable communications needs.

The scientific exploration of outer space is accomplished by the use of deep space probes. The data these probes accumulate must be transmitted to earth, and the earth station must be able to send commands to the probes at various points along their paths. This requires a two-way communications link between the earth and the probe.

3. Program phasing

During the fiscal year 1959, work was initiated on Project ECHO—a project to place several 100-foot diameter inflatable spheres into circular orbits about the earth. These spheres will be used to reflect passively electromagnetic energy from one ground station to another. Part of the project is the development of the sphere itself, its packaging into a payload, and methods of inflating and ejecting the sphere from the final booster stage. A 12-foot diameter version of

this sphere, which was also to furnish data for air density studies, was launched in August 1959 but failed to achieve orbital velocity. The development of a beacon to aid in the tracking of the satellites was started in the fiscal year 1959. Improvements were also made to the JPL Goldstone transmitter and receiving sites at the Jet Propulsion Laboratory.

In the fiscal year 1960, the large-sphere flight research program will be initiated. Several 100-foot diameter inflatable sphere payloads will be ejected from boosters in vertical suborbital shots to test ejection and inflation techniques. Following this, a 100-foot sphere will be launched to orbit. Communication experiments will be conducted between east and west coast transmitting and receiving stations, using the sphere as a passive relay.

Research and development will be conducted in the fiscal year 1960 in several areas. In the area of inflatable structures for use as passive reflector satellites, work will be done on radio propagation characteristics, the feasibility and development of larger structures, and on rigidization techniques. Studies will be undertaken in the field of world communications needs, of communication satellite system requirements to fulfill these needs, and of the ground support systems required for their use. These studies will be directed toward providing recommendations for the optimum communications satellite system.

The fiscal year 1961 program is a continuation and broadening of the 1960 program. Additional 100-foot spheres will be launched for further communications experiments. Since a worldwide passive satellite communications system will require several satellites simultaneously in orbit, the development of a multisphere payload for launch by a single vehicle will be started. One of these will be launched in 1962. Data transmission requirements will be studied, with emphasis on a data relay for meteorological satellites. The advanced equipment development program will result in prototype models of a high-gain antenna and mount. Development of suitable modulation systems will be initiated.

During the fiscal years 1960 and 1961, work on active relay satellites will be limited to studies on the civilian and commercial applications of these satellites, the requirements imposed by commercial needs on such satellites, and the application of pertinent developments resulting from the Department of Defense program.

During the fiscal year 1959, work in the area of deep space communications was carried out by the Jet Propulsion Laboratory as part of its JUNO II program. Their work included the design of a space vehicle communications and tracking system for the PIONEER III and IV experiments and the evaluation and improvement of elements of existing systems.

In the fiscal year 1960 studies will be made to determine the requirements for deep space communications, and the development of new components will be continued. Fiscal year 1961 will continue studies and component development, and will provide for communications equipment for use in planned deep space experiments.

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Advanced technical development:			
Communications satellite studies and equipment development	$284,806	$740,000	$1,100,000
Deep space communications studies and equipment development		400,000	350,000
Flight research program:			
Boosters	2,150,000		
Payload development, procurement, and operation	1,140,000	2,030,000	4,150,000
Total	3,574,806	3,170,000	5,600,000

Mr. THOMAS. For your communications you are requesting the sum of $5.6 million.

MANNED SPACE FLIGHT

With reference to manned space flight we shall insert into the record at this point pages 164 through 167–1 and 167–2 of the justifications.

(The pages referred to follow:)

MANNED SPACE FLIGHT

Fiscal year 1959	$46,416,333
Fiscal year 1960	[1] 87,162,000
Fiscal year 1961	107,750,000

[1] Includes $12,200,000 requested in fiscal year 1960 supplemental estimates.

1. Objectives

To provide a capability for accomplishing advanced space flight missions with vehicles where onboard human intelligence and operations are required; to rationalize and refine the technology of manned space flight vehicles and associated systems; to achieve successful orbital flight and the recovery of a manned satellite with an ICBM booster and drag-reentry system; to evaluate the physiological and psychological effects of a space environment on man; to establish his capabilities and limitations for performing useful missions in space; and to devise and develop improved manned vehicles with increased capabilities for performing important missions.

2. Justification

The ultimate benefits that might accrue from manned space flight are, in a large measure, unknown. It is clear, however, that instrumentation alone will not tell us as much about the moon, or the planets, as man himself will be able to report once he has visited those distant places. Man contributes observational, analytical, and decisionmaking ability concerning both expected and unanticipated problems. He provides a vast flexibility of action for operation, correction, and maintenance of scientific and technological instrumentation and equipment that characterize his present usefulness in airplanes and in the scientific laboratory.

In order to provide the capability for the manned exploration of space, a progressive program of research and development has been undertaken. A broad range of investigations, directed to the solution of basic technological problems concerning vehicular configurations and construction, human factors, life-support equipment and accommodations, launching systems, stabilization and control, reentry and recovery systems and techniques, operational and scientific instrumentation, and other vehicular subsystems, is underway. These investigations are presently directed toward solution of the problems associated with the Nation's first manned venture into orbit—Project MERCURY. On the basis of extensive studies, it was determined that Project MERCURY should be based on the use of an ICBM booster launching system and on a ballistic type of reentry into the atmosphere. The use of ballistic reentry offers the best potentiality for early success because of the relative simplicity and reliability of this approach. However, ballistic reentry pays for its simplicity with landing point dispersions that will be operationally and economically unacceptable for extended use. As Project MERCURY nears completion, extensive studies and configuration tests in wind tunnels and free flight will be undertaken as part of a program to develop the capability for landing point control.

A crucial part of the system for attaining landing point control is the stabilization and control system. It is important that this system be capable of both manual and automatic operation, in order to enhance reliability through human backup and in order to allow for the use of onboard human judgment to vary the landing site choice. A comprehensive study, including flight simulators for pilot training, will be required to provide this capability.

In order to meet the foremost objective of Project MERCURY—the attainment of manned orbital flight at the earliest practicable date—additional funds in the amount of $12,200,000 have been requested as a fiscal year 1960 supplemental estimate. The additional $12,200,000 is required to pay for contractor overruns, changes in capsule design and construction, and for added capsule requirements. The design changes and added requirements have arisen as a result of development tests and a continuing analysis of safety requirements. The compressed time phasing of Project MERCURY between inception and scheduled flight has required that research, development, design, and fabrication be undertaken simultaneously. Under these conditions, experience has required that modifications to design, arrangement, and structure be made during the conduct of the program. Efforts to make the Project MERCURY system as safe as humanly

possible have inevitably added to the cost, as detailed analyses have uncovered new schemes for enhancing the safety and reliability of the system.

3. Program phasing

During the fiscal year 1959, much of the preflight research and development effort for Project MERCURY was accomplished and contracts were let for major components of the system. Specifications for the worldwide radio-tracking network were prepared and sent out to prospective contractors.

During the fiscal year 1960, the major part of the MERCURY preflight- and flight-development program will be completed, and component qualification and astronaut training flights will be initiated. The tracking network will near completion during this period.

During the fiscal year 1961, it is anticipated that the MERCURY qualification programs will be essentially completed and that the tracking network will become operational. Large expenditures for the recovery operations and for the operation of the tracking network will be added to flight hardware purchases.

Systems for achieving landing-point control will also be under study during the fiscal year 1961. In this connection, two major problem areas require immediate attention: The use of lift to reduce the landing area, and guidance and control methods for piloted landings. Extensive analyses will be made, and scale models of controllable reentry vehicles will be evaluated in wind tunnels. Flight simulators will be used to evaluate the pilot's capability to fly such vehicles.

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Advanced technical development:			
Biological and human engineering studies	$170,000	$2,180,000	$2,090,000
MERCURY development program	3,100,000	5,270,000	4,050,000
Advanced reentry configuration			800,000
Manual and automatic guidance and control systems for advanced reentry configuration		100,000	200,000
Flight research program:			
ATLAS and REDSTONE boosters	20,840,000	23,460,000	25,650,000
MERCURY capsules, support equipment, and support services	22,299,333	[1] 47,212,000	35,290,000
Tracking network operations and equipment	7,000	5,410,000	24,670,000
Recovery operations		3,530,000	15,000,000
Total	46,416,333	[1] 87,162,000	107,750,000

[1] Includes $12,200,000 requested in fiscal year 1960 supplemental estimates.

OBJECTIVES

Our long-range plans for the exploration of space are based on the premise that man will actively participate in many of our space missions. These plans, therefore, strongly depend on the assumption that manned space flight is feasible, and that man will indeed be able to perform useful functions in space. Much of our future effort depends on the validity of this assumption, and it is therefore imperative that man's capabilities in space be determined as soon as possible.

Project MERCURY was conceived, and is being carried out, in a manner that will attempt to achieve manned orbital flight at the earliest practicable date. Its primary objective is to determine man's capabilities in a space environment.

In the MERCURY mission, a satellite capsule will be launched into a 120-mile orbit, using an ATLAS booster. The capsule will be fitted with an escape system, designed to separate it from the ATLAS in case of a booster malfunction. In a normal mission, the satellite will circle the globe three times; at the end of three orbits, the capsule's retrorockets will be fired to initiate its descent toward the atmosphere. During its flight within the atmosphere, it will be slowed down, by the drag of the air through which it flies, to a speed where the landing parachutes can safely be deployed. After a parachute landing in the Atlantic Ocean, the capsule will be picked up by recovery ships that are standing by.

The accomplishment of Project MERCURY will mark a tremendous step forward; putting a man into space will immeasurably extend the frontiers of manned flight. The speed of flight will be increased by a factor of 8 over present

achievements, and the altitude by a factor of 5; the environment encountered in space flight will be one that heretofore has not even been approached.

RESEARCH AND DEVELOPMENT PROGRAM

Because the ultimate achievement of manned orbital flight will constitute a stretching of the existing state of the art, its accomplishment requires a logical and methodical buildup of capability. As a part of this buildup, broad scientific and engineering investigations have been undertaken, using a wide variety of technical equipment, to determine a suitable shape for the manned satellite capsule.

Following these investigations, a flight program was initiated to develop and qualify the various components of the capsule. A MERCURY flight schedule is shown on a following page. The flight program includes airplane drop tests, in which full-scale capsule models were dropped from large cargo aircraft at high altitude. The tests were used to develop a highly reliable parachute system, and to determine procedures to be used in the recovery operations. In other tests, capsule models were released from fighter aircraft at supersonic speeds, to develop and qualify the capsule's drogue parachute. The escape system was perfected by launching full-scale capsules with the escape rocket as the only means of propulsion.

Rocket-boosted flight tests were required to check the capsule and its components over a range of speeds and altitudes. A solid-propellent rocket booster, nicknamed LITTLE JOE, was designed and fabricated especially for Project MERCURY. This booster, which develops 2¼ million pounds of thrust at takeoff, was used on a number of occasions to further aid in the qualification of the all-important emergency-escape system.

The validity of the MERCURY design concept was demonstrated in the fall of 1959 during an ATLAS-boosted capsule test, called BIG JOE. In that test, a capsule was made to reenter the earth's atmosphere, after being accelerated to nearly orbital speed. The BIG JOE capsule, which survived the scorching heat of reentry, was later recovered many hundreds of miles from Cape Canaveral.

To date, more than 100 wind-tunnel tests of the MERCURY capsule have been performed; and 122 capsule models have been dropped from airplanes in the parachute development program. The escape system has been tested three times in simulated off-the-pad abort maneuvers, and four more escape-system tests were performed in connection with four successful LITTLE JOE flights. A small monkey was carried along on two of the LITTLE JOE flights, in an attempt to gain further physiological data on the effects of space flight. And, as mentioned earlier, a single ATLAS-launched capsule flight has been made.

Mr. THOMAS. You are requesting in 1961 the sum of $107,750,000 as against $87,162,000 in 1960, and $46,416,333 in fiscal year 1959.

The sum of $87,162,000 for fiscal year 1960 includes your supplemental of $12.2 million.

These figures are broken down into your ATLAS and REDSTONE boosters in the amount of $25,650,000; your MERCURY capsules, support equipment, and support services in the amount of $35,290,000; your tracking network operations and equipment in the amount of $24,670,000, and your recovery operations in the amount of $15 million.

When do you think we will be able to make this?

Dr. DRYDEN. The REDSTONE flight later this year and the orbital flight during the next calendar year, are the best estimates at present.

Mr. THOMAS. These are tremendous figures. The breakdown here involves so many figures they do not mean much to me.

What part of them are guesswork and what part of them are estimates? What part of them are firm out of your whole figure of $107 million? It is virtually impossible to come up with a firm estimate on a proposition of this nature.

How much of this $87,162,000 will you commit during fiscal year 1960, or what will be your carryover?

Mr. ULMER. In this program, most of the funds will be obligated by the end of the year. We have currently under obligation and committed about $60 million, Mr. Thomas.

Mr. THOMAS. How many contracts are involved in this sum of money?

Mr. ULMER. Probably 40 or 50, and one of the major contracts is a contract with the capsule contractor, but there are dozens of small ones.

Mr. THOMAS. That is the biggest item in it and that contract is with the McDonnell Co., is it not?

Mr. ULMER. Yes, sir.

Mr. THOMAS. What is that contract? That is for the capsule, is it not?

Mr. HORNER. I think that is the biggest single item.

Mr. THOMAS. What was that? Was it $24 million?

Mr. HORNER. It is $35 million this year.

Mr. ULMER. It is $35,290,000.

EQUIPMENT AND SUPPORT FOR RESEARCH AND DEVELOPMENT PROGRAM

Mr. THOMAS. On what page does that information appear?

Mr. ULMER. Pages 167–20 and 167–21.

Mr. THOMAS. We shall insert those pages into the record at this point.

(The pages referred to follow:)

Equipment and support for the research and development program.—This is McDonnell production-type equipment used in the research and development program, as opposed to the actual MERCURY missions. It includes, for example, the capsule-ATLAS adapter for the BIG JOE test, and the escape towers and rockets used in the LITTLE JOE tests. Other typical equipment in this category includes special capsule equipment for the animal program, and onboard communications equipment to be installed in airplanes that will be used to check out the worldwide tracking and communications network.

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Basic contract (12 identical capsules):			
Engineering	$2,640,000	$1,400,000	$113,000
Tooling	807,000	429,000	36,000
Experimental construction	1,327,000	705,000	53,000
Capsule, system, and subsystem construction	6,850,000	3,640,000	300,000
Fee	716,000	386,000	48,000
Total	12,340,000	6,560,000	550,000
Contractor additional costs:			
Engineering	930,000	801,794	
Tooling	−18,400	−16,007	
Experimental construction	−204,000	−174,363	
Capsule, system, and subsystem construction	3,960,000	3,347,357	
Capsule delivery change	800,000	200,000	
Inspection	167,601	107,151	
Total	5,635,201	4,265,932	
Anticipated additional costs for services within present scope of work:			
Engineering		2,030,000	2,170,000
Experimental construction and production		620,000	765,000
Capsule, system, and subsystem construction		4,720,000	6,132,000
Inspection		230,000	283,000
Total		7,600,000	9,350,000
Training simulators:			
Procedures trainer		1,839,903	418,000
Couches, restraint systems		175,000	47,000
MAC personnel services and minor changes		75,000	38,000
Air bearing trainer equipment		25,000	47,000
Total		2,114,903	550,000
Capsule changes	359,389	8,528,701	4,750,000
Spare parts	1,565,212		360,000
Additional capsules:			
2 additional capsules		3,228,427	330,000
6 additional capsules		6,060,273	5,590,000
4 additional capsules			8,400,000
Total		9,288,700	14,320,000
Ground support equipment	1,094,890	5,689,375	1,630,000
Flight test support		820,000	2,300,000
R. & D. support equipment and services	1,304,641	2,344,389	1,480,000
Total	22,299,333	[1] 47,212,000	35,290,000

[1] Includes $12,200,000 in pending fiscal year 1960 supplemental estimates.

Mr. THOMAS. This is the McDonnell contract?

Mr. ULMER. That whole table relates to the McDonnell contract.

Mr. THOMAS. It includes, for example, the capsule—ATLAS adaptor for the BIG JOE test."

Is all this money spent with McDonnell? You had to change it in the last 4 or 5 months, did you not?

Dr. DRYDEN. Those pages relate to the McDonnell contract.

Mr. THOMAS. This table shows you spent $47,212,000 in fiscal year 1960 as against $22,299,333 in 1959.

Dr. DRYDEN. That is right.

Mr. THOMAS. Will it be completed in fiscal year 1961?

Dr. DRYDEN. It will certainly be finished in calendar year 1961.

Mr. THOMAS. Will there be any added expenditures other than what you have scheduled here?

Dr. SILVERSTEIN. Not for the MERCURY program directly. There will be a follow-on to the MERCURY program which will carry on beyond 1961. That is the advanced MERCURY program,

but the program as we have described it and the flights we have described for it——

Mr. THOMAS. Suppose it is a success? What are you doing? Suppose it is a medium success? What will you do? Suppose we meet with disaster? What are your plans under the three different circumstances?

Dr. DRYDEN. I just wanted to correct one thing: Some of the flights will occur beyond the end of fiscal 1961 and there will be operational costs connected with those flights. If MERCURY is a success, there will be a follow-on program with life and control of the vehicle, so that its path can be changed. If it is a failure, of course, the whole manned space flight situation would be up in the air, or perhaps more accurately, down on the ground.

VEHICLE SYSTEMS TECHNOLOGY

Mr. THOMAS. We shall insert into the record at this point pages 168, 169, and 170 of the justifications.

(The pages referred to follow:)

VEHICLE SYSTEMS TECHNOLOGY

Fiscal year 1959	$1,903,651
Fiscal year 1960	6,737,000
Fiscal year 1961	21,200,000

1. Objectives

To conduct studies and to develop materials, components, subsystems, and systems which will provide the optimum structure, configuration, guidance, control, and orientation and auxiliary power systems for space investigations such as deep space missions, lunar missions, and earth satellite projects.

2. Justification

Space exploration depends upon guidance, control, attitude, and stabilization equipment for placing vehicles into the desired trajectories and with the desired orientation. Much of the guidance and stabilization technology which has been developed for the ballistic missile is applicable to space exploration. For example, injection guidance for space missions may be directly appropriated from ballistic missile experience, with only the additional developments required to produce lighter weight systems and to adapt existing knowledge and guidance technology to larger boosters such as the SATURN. However, the total requirements generated by space missions are different in both kind and degree. Consequently, development effort is required to provide vehicle and component control at great distances from the earth. These developments relate to components and systems for sensing and modifying the velocity of spacecraft in a manner to follow prescribed trajectories. They also are needed for stabilizing spacecraft and components with respect to known coordinate systems such as those involved in establishing a proper propulsion thrust vector, controlling temperature through heat absorption or radiation, or in collecting solar energy. Further system developments are needed for sensing position and orientation of spacecraft, subsystems or components, and for providing reaction forces to modify the orientation required in such applications as maintaining communication through the use of high-gain antennas.

Successful space missions also depend upon the protection of scientific instruments from the hostile environment of space. The pursuit of this objective leads to research on materials to provide protection through the fabrication of durable but light-weight structures or by the development of resistive materials from which components or instruments can be assembled.

In the area of vehicle engineering, emphasis is on structural aspects and integration aspects of the variety of subsystems which compose the spacecraft. As a part of this effort there is a study on types of propulsion systems which should be used under different conditions; studies on landing techniques; and a look at the general problems of entry and reentry.

3. Program phasing

Guidance and control activities during the fiscal year 1959 were restricted to research on components and to a study of NASA space mission requirements, with the objective of defining a productive guidance approach. During the fiscal year 1960, the first steps outlined in the guidance study are being undertaken: (1) the start of work on a first generation, or phase I, inertial injection guidance system utilizing analog techniques and guiding all stages of the launch booster, (2) start on a phase II inertial guidance system utilizing digital techniques and possessing great flexibility in programing, and (3) the development of a completely digital precision autopilot for use in earth satellite missions which require supervision through burnout of the final boosted stage but which can be accomplished with less expensive control mechanisms. Radio guidance techniques were extended to the post injection, or midcourse, portion of space flight. Efforts at first generation vehicle-contained midcourse guidance, terminal guidance and attitude control will be undertaken during the fiscal year 1960 in the spacecraft developed as the connecting link between the capability of the AGENA B booster and the desired circumlunar, or rough lunar landing missions.

In the fiscal year 1961 a start will be made on vehicle-contained capability for trajectory corrections. Terminal guidance and attitude control will be continued in conjunction with the development of more sophisticated spacecraft to be carried on advanced boosters.

Guidance and control equipment will be designed to provide the capability of circumnavigating a celestial body, establishing precise orbits, circularizing elliptical orbits at prescribed altitudes, controlling the approach and letdown for soft landings, and providing a means for sample return from the Moon and reentry into the Earth's atmosphere either from escape velocity or from a satellite orbit. This will be accomplished through the evolutional development of vehicle-carried systems. Component development for controls and sensors must be carried on at a parallel rate.

Materials research will require increased emphasis during the fiscal year 1961 to provide knowledge relating to the behavior of materials under the three conditions of thermal equilibrium—namely, space flight, the cold lunar night, and the lunar day with its high level of infrared reflection; to thermal shocks resulting from transitions between these stages of equilibrium; and relating to the effects on materials during reentry from either escape velocity or satellite orbits.

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Advanced technical development:			
Development of injection guidance systems		$3,804,000	$1,800,000
Development of midcourse guidance systems		50,000	1,300,000
Development of terminal guidance systems			250,000
Development of attitude control systems			200,000
Development of guidance and control system for CENTAUR-boosted spacecraft			13,000,000
Development of guidance and control system for SATURN-boosted spacecraft		250,000	1,650,000
Vehicle engineering		1,708,000	1,000,000
Advanced technical developments, components, and materials	$1,903,651	925,000	2,000,000
Total	1,903,651	6,737,000	21,200,000

Mr. THOMAS. This is your vehicle systems technology. Your justifications state the objectives as follows:

To conduct studies and to develop materials, components, subsystems, and systems which will provide the optimum structure, configuration, guidance, control, and orientation and auxiliary power systems for space investigations such as deep space missions, lunar missions, and earth satellite projects.

Well, you have everything in the book in this, have you not?

Dr. DRYDEN. The first section of this relates largely to guidance and control systems. Then, there is a section on vehicle engineering dealing with the——

Mr. THOMAS. I note that you have an item for the development of injection guidance systems.

With whom are you spending that money which is in the sum of $1.8 million in fiscal year 1961 and was $3,804,000 in fiscal year 1960?

Then, you have the development of midcourse guidance systems in the amount of $1.3 million and your development of guidance and control system for CENTAUR-boosted spacecraft in the amount of $13 million.

That is a new item, is it not?

Dr. SILVERSTEIN. That will be under our contract with JPL—this item of $13 million. That is a part of the funds which support their operation, because they are the prime contractor and they will, in turn, subcontract a large percentage of this out to industry.

Mr. THOMAS. It would be a whole lot clearer and more understandable if you would list those activities at the JPL laboratory instead of chasing these items from one book to another. If you would put them under that laboratory, we would know exactly what is going on and what you are paying for it. If the Bureau of the Budget wants you to work and use a performance budget, we have no objection to your working out one for them.

Dr. DRYDEN. All of the contracts for R. & D. will be administered through JPL, Goddard, and, in a few instances, from headquarters still.

Mr. THOMAS. Gentlemen, we will proceed to consideration of the next item.

SOLID ROCKETS

Mr. THOMAS. For solid rockets your request is in the amount of $2.8 million as against $3,785,000 in fiscal year 1960.

At this point in the record we shall insert pages 171 through 173 of the justifications.

(The pages referred to follow:)

SOLID ROCKETS

Fiscal year 1959	$615,898
Fiscal year 1960	3,785,000
Fiscal year 1961	2,800,000

1. Objectives

To establish, on an experimental basis, the background which will allow exploitation for space vehicle use of the high reliability, simplicity, and economy of solid propellant engines; demonstrate advanced techniques in the use of very high performance solid rockets as upper stages and as auxiliary rockets for space vehicles; develop techniques for improving the utility and versatility of solid propellant rockets by devising improved and advanced methods for thrust vectoring, modulation, and termination; conduct studies and experimental programs to establish the application of solid propellant motors as first-stage high-thrust boosters for space vehicles; and to explore techniques for exploiting the properties of solid rockets for sounding vehicles to obtain greater simplicity and economy.

2. Justification

Solid propellant rockets have several inherent advantages. From a logistic and handling standpoint, they are storable for extended periods of time, they utilize simple operating principles, they involve essentially no complex machinery, they are generally transportable in the loaded condition, and they offer advantages of simple firing techniques for relatively untrained launching crews. These general characteristics make for high reliability and, in general, lower costs in development and use compared to liquid rocket systems. The basic char-

acteristics of solid rockets also allow them to be fabricatd readily in different sizes on a short development time scale.

From a performance standpoint, solid propellant rockets have two inherent characteristics which can be exploited to great advantage for propulsion in space booster vehicles. First, the physical properties of solid rockets allow them to be constructed to very high ratios of propellant to inert parts when employed as upper stages in a vacuum environment. The second advantageous performance characteristic is the ease with which thrust levels can be varied. It is not distinctly more difficult or expensive to develop thrust levels of 1 million pounds as compared to the 100,000 to 500,000 pound thrust levels now employed.

The utility of solid rockets is limited by the present cumbersome and relatively inefficient techniques for controlling thrust level during burning, for terminating thrust, and for obtaining thrust directional control. In addition, the inability to reignite a solid motor after initial termination decreases its utility as a terminal stage or as a retrorocket. While high propellant-mass ratios of 0.96 to 0.97 are achievable in solid rockets, little has been done to demonstrate on a significant size scale the achievement of such performance.

The proposed program will aim at improvement of the deficiencies discussed above and at the demonstration of some of the performance, reliability, and logistic advantages of solid rockets. A program will be continued to evaluate and develop new propellants for space propulsion as new ingredients and propellent materials become available.

3. Program phasing

The solid rocket program is divided into four parts as follows:

High performance motors.—In the fiscal year 1959, work was initiated to demonstrate the feasibility of rocket motors with a propellant to loaded motor weight ratio of 0.96. In the fiscal year 1960, a limited number of static firings are being conducted to prove out these designs. In the fiscal year 1961, work will be continued on advanced techniques for achieving ratios of 0.96 and beyond, and for solving associated propellent geometry, case, and nozzle design and development problems. Advanced techniques for achieving economical sounding rockets of high performance will also be explored. Sufficient data should be available by the fiscal year 1961 to conduct design studies and initiate development of very high performance terminal stages for specific space vehicles.

Advanced thrust modulation and vectoring systems.—Limited work was initiated during the fiscal year 1959 on exploring the feasibility of thrust modulation by ultrasonics. The 1960 program is expanding the effort on thrust modulation and includes work on the exploration of new techniques for thrust vectoring and thrust termination. In the fiscal year 1961 work will be continued on the most promising programs. Studies to apply some of the advanced techniques to specific solid motors will also be initiated.

High performance propellent systems.—In the fiscal year 1959 work was initiated on the evaluation of new propellents and ingredients, and on their incorporation into propellent systems for application to the unique needs of space propulsion systems. This effort will be continued in the fiscal years 1960 and 1961 with particular emphasis on exploiting the new ingredients and materials that are being synthesized and developed under programs sponsored by the Department of Defense.

Improved motor materials and manufacturing techniques.—Solid rockets for space applications require manufacturing techniques of high reliability and precision. Fiscal years 1959 and 1960 programs were initiated on nondestructive inspection techniques, inspection criteria, and on advanced methods of fabricating rockets, such as building a loaded rocket motor in separate sections and then assembling them. These programs will be continued, and the nondestructive testing techniques and inspection criteria developed will be applied to motors actually being manufactured for application to space vehicles.

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Advanced technical development:			
High-performance motors	$260,898	$1,515,000	$1,300,000
Advanced thrust modulation and vectoring systems	90,000	930,000	500,000
High-performance propellent system	175,000	910,000	700,000
Improved motor materials and manufacturing techniques	90,000	430,000	300,000
Total	615,898	3,785,000	2,800,000

Liquid Rockets

Mr. Thomas. The next item is your liquid rockets wherein the request is $63 million for fiscal year 1961.

We shall insert at this point in the record pages 174, 175, and 176 of the justifications.

(The pages referred to follow:)

Liquid Rockets

Fiscal year 1959	$15,978,589
Fiscal year 1960	30,328,000
Fiscal year 1961	63,000,000

1. Objectives

To develop an advanced capability for launching and propelling payloads for space exploration through the use of liquid propellent rocket engines; to improve the performance of space vehicles through the development of improved propellants and equipment; and to work out practical solutions for the technical problems occurring in development and operation of liquid propellent engines.

2. Justification

The liquid propellent rocket is the mainstay for propulsion of the present and coming generation of space vehicles. To provide capability for launching and propelling payloads for space exploration requires the development of several new high-performance engines of different thrust levels. These include a large booster engine, engines using hydrogen-oxygen propellants in upper stages, and engines using propellants that are storable for prolonged periods of time in the space environment.

For missions aimed at launching large manned vehicles into orbit around the earth or for delivering large instrumented payloads on the surfaces of the planets, booster thrust levels significantly greater than those of ICBM engines are needed. Accordingly, a 1,500,000-pound thrust engine is now under development. Manned vehicular landings on the surface of the moon or planets with return can be accomplished by clustering 4 to 6 of these engines into a first-stage booster.

The full payload carrying capability of the booster engines can only be realized by the use of upper stages equipped with engines using high-energy propellants. The use of hydrogen-oxygen as the propellant for upper stages of space vehicles will increase carrying capability about 50 percent per stage as compared to hydrocarbon-oxygen engines. One large engine using hydrogen-oxygen propellants is now under development. Experimental tests have demonstrated the feasibility of building an engine with a thrust level suitable for use with advanced vehicles on space missions.

3. Program phasing

A contract to develop a single-chamber engine of 1,500,000 pounds thrust was let in 1959. During the fiscal year 1959, thrust chamber hardware was fabricated and preliminary thrust chamber tests were begun. Other components of the engine were designed. Modification of existing test facilities to accommodate this engine and construction of one new test facility necessary for engine testing were undertaken by the Air Force. Fabrication of engine components and extensive testing of all elements of the engine will be started during the

fiscal year 1960. Initial assembled engine tests with continued component development are scheduled for the fiscal year 1961.

During the fiscal year 1960 a development effort will be initiated on a large engine using high-energy propellants for application to advanced vehicles.

Applied research and experimentation as well as analytical investigations on advanced engine types will be carried out. Applied research on engine problems in the fiscal year 1959 was devoted to a determination of the feasibility of large thrust single chamber boosters. In the fiscal year 1960 applied research will include analytical and experimental investigations into causes and methods of avoiding combustion oscillations in large rocket engines, and applied research required in further development of the 6,000-pound thrust storable propellent rocket. In the fiscal year 1961 applied research funds will be used to continue the combustion oscillation investigations started in the fiscal year 1960, and to start a project to investigate liquid propellants capable of being stored in a space environment for prolonged time periods.

The fiscal year 1961 advanced engine design investigations will include an investigation to determine methods of simulating operational characteristics of large engines through model tests; and the continuation of injector, thrust chamber, heat transfer, and chamber fabrication investigation pertinent to storable-propellent engines.

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Advanced technical development:			
Advanced engine design investigations	$3,558,589	$3,688,000	$3,400,000
Applied research on engine problems	420,000	1,470,000	1,800,000
Development of 1,500,000-pound thrust booster rocket engine	10,000,000	24,200,000	41,000,000
Development of hydrogen-oxygen upper-stage engines			16,000,000
Development of storable-propellant engines	2,000,000	970,000	800,000
Total	15,978,589	30,328,000	63,000,000

Mr. THOMAS. You are getting into real money again. You are requesting $63 million for fiscal year 1961 as against $30,328,000 in fiscal year 1960 and as against $15,978,589 in fiscal year 1959.

Where is this money spent?

Your justification states as follows:

To develop an advanced capability for launching and propelling payloads for space exploration through the use of liquid propellant rocket engines; to improve the performance of space vehicles through the development of improved propellants and equipment; and to work out practical solutions for the technical problems occurring in development and operation of liquid propellant engines.

Is this projected for 1968 or 1969?

Dr. DRYDEN. Two-thirds of this is on the F–1 engine—which we have discussed before—in the amount of $41 million; $16 million is on the hydrogen-oxygen engine that Dr. von Braun spoke about. The other $3.4 million is on advanced engine design investigations. It is for study of the so-called plug-nozzle engine on which some research has already been carried on and financed—and about which you may have read in advertisements of some companies. It is not quite clear yet whether this should be carried to the development stage.

COST FOR DEVELOPMENT OF 1,500,000-POUND THRUST BOOSTER ROCKET ENGINE

Mr. THOMAS. We will insert into the record at this point the table which appears at the bottom of page 176–3 of the justifications.

(The table referred to follows:)

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Preliminary design	$751,000		
Component development	3,791,000	$12,596,000	$16,119,000
Component test	622,000	2,197,000	3,848,000
Engine development	408,000	5,755,000	14,683,000
Engine test			2,325,000
Fabrication and test equipment	4,428,000	2,452,000	317,000
Propellants		1,200,000	3,708,000
Total	10,000,000	24,200,000	41,000,000

Mr. THOMAS. For preliminary design you have no request in fiscal year 1961 but for component development you have a request in the amount of $16,119,000 and for component test you have the sum of $3,848,000.

For engine development you have the sum of $14,683,000 and for engine test you have the sum of $2,325,000.

Where are you going to spend this money?

Dr. DRYDEN. At North American Rocketdyne Division.

Mr. THOMAS. Is this under the JPL laboratory?

General OSTRANDER. No, sir; this is done through Huntsville.

Mr. THOMAS. This is a part of Dr. von Braun's work down there?

Dr. DRYDEN. This will be monitored by Dr. von Braun.

Mr. THOMAS. The whole $63 million is an adjunct to his activities?

General OSTRANDER. Yes, sir.

Dr. DRYDEN. The two big items are the 1.5 million pound thrust engine and the hydrogen-oxygen engine.

Mr. HORNER. There is one small item of $800,000 which will go to JPL for storable propellants.

General OSTRANDER. There are actually three items which include the 1,500,000-pound thrust engine, the 200,000-pound thrust hydrogen-oxygen engine and the last one is the small one which will be under JPL.

Mr. THOMAS. You have an $800,000 item now and you have more than three items; have you not?

General OSTRANDER. Those are the three engine items. We have a number of advanced technological items.

Mr. THOMAS. You are working on three engines. Your money is split over your three engines?

General OSTRANDER. Yes, sir.

Mr. THOMAS. The preliminary design is in the amount of $585,000; your component development is in the amount of $4,686,000—and that is for your 200,000-pound thrust hydrogen-oxygen engine?

General OSTRANDER. Yes, sir.

Mr. THOMAS. Then, you have your 1,500,000-pound thrust engine?

Dr. DRYDEN. Yes, sir; 1½ million pounds.

Mr. THOMAS. And that is in the amount of $5.2 million.

General OSTRANDER. These are for a number of advanced technological developments including this plug nozzle that Dr. Dryden spoke of, and investigation of hydrogen-oxygen problems in flight.

Mr. THOMAS. Those are preliminary. Your budget includes $41 million for your 1,500,000-pound engine; does it not?

Dr. DRYDEN. That is correct.

Mr. HORNER. Those first two items are broken down on the top of page 176.

NUCLEAR SYSTEMS TECHNOLOGY

Mr. THOMAS. The next item is your nuclear systems technology wherein you are requesting $10 million for fiscal year 1961. You had $6 million for fiscal year 1960.

Where is this money being spent?

We shall insert into the record at this point pages 177 through 180 and 180–1 and 180–2 of the justifications.

(The pages referred to follow:)

NUCLEAR SYSTEMS TECHNOLOGY

Fiscal year 1959	$3,810,496
Fiscal year 1960	6,000,000
Fiscal year 1961	10,000,000

1. Objectives

To develop the components and technology required to permit the development of nuclear-powered systems to deliver large payloads to interplanetary objectives. The current emphasis in this program is on solution of the many technological problems that now stand in the way of nuclear system development.

2. Justification

The two principal types of nuclear systems that are considered suitable for the propulsion of high payload rocket systems in space are the nuclear heat transfer rocket system and the electrical propulsion system using a nuclear reactor system to generate electrical power. The nuclear systems technology program supports the work on the nuclear heat transfer rocket system and on the nuclear reactor electric power generating systems.

Th nuclear heat transfer rocket is a system in which hydrogen is heated to high temperatures in a nuclear reactor to produce specific impulses in the range of 700 to 1,000 pounds of thrust per pound of hydrogen flowing per second. The high specific impulse potentially available from the nuclear heat transfer rocket permits the delivery of large payloads for various missions requiring high energy. The nuclear rocket can be used in booster rocket systems as well as in the space environment. Although early emphasis in the nuclear heat transfer rocket program was on research aimed at the development of large thrust or high reactor power first-stage rockets, the current goals of the program are aimed at accumulating the necessary research information required to develop a reactor flight test system that would be launched by chemical rockets. Such a system could eventually be incorporated into a space vehicle stage which would take off for its interplanetary objective after having been launched into an earth orbit by large chemical rockets. In this program, the NASA is working with the Atomic Energy Commission.

Nuclear reactor electrical power generating systems are required to supply the electrical power needed to accelerate charged particles or neutral plasmas to high velocities in order to produce thrust in the electrical propulsion systems which appear to have good capabilities for space missions. (The accelerator or thrust production components of the electrical propulsion systems are discussed under the program entitled "Space power technology.") Analyses of space mission capabilities of these electrical propulsion systems have indicated that such systems will be competitive with the low-thrust nuclear heat transfer rocket system described above. One of the disadvantages of the electrical propulsion system is the long trip time involved as the result of the low ratio of thrust-to-stage weight. One of the advantages of the electrical propulsion system is that the electrical generating equipment may be used for communications when the payload has been propelled to its planetary objective.

It is one of the purposes of the present program to do the research necessary to develop high-power, lightweight nulclear reactor electric generating systems. It is felt that the development of such high-power systems must wait for the accumulation of various fundamental data and research on critical components of the system. In addition to the funds required for applied research leading to advanced high-power systems, funds are included in this program to continue the development of a system for converting energy from nuclear heat to electrical

power using currently available information. This conversion system will be matched with the SNAP–8 reactor being developed at the request of the NASA by the Atomic Energy Commission. This reactor electric system will produce enough power to supply communications needs for planetary missions as well as to test early versions of electrical propulsion systems.

3. Program phasing

The work under this program is divided into nuclear reactor electric generating systems and nuclear heat transfer rockets. The fiscal year 1959 funds for nuclear reactor electric generating systems were used to design conversion equipment for a nuclear electric system (SNAP–8) and to initiate fabrication of the components. In addition, work was started on the acquisition of data that will be required in the design of higher power, higher temperature systems. Funds for the support of the nuclear heat transfer rocket reactor test program were transferred to the Atomic Energy Commission to undertake the development of a pump that will be used in the test program. In addition, funds were used to initiate experiments (such as the effect of radiation on the properties of materials at cryogenic temperatures) that will supply information necessary in the eventual design and operation of nuclear rockets.

In the fiscal year 1960, the components of the nuclear electric system will be fabricated and component testing will be initiated. The work on the fundamental information required to permit the design of higher power, higher temperature systems will be expanded. For instance, work will be undertaken on the corrosion characteristics of high-temperature working fluids. The support of the reactor test program will be expanded. The development of a pump for operation under the conditions required for early reactor testing will be completed, and research and development on a pump-drive system will be undertaken. Work on the fundamental information that will be required in the design of nuclear rockets will be expanded. For example, work on shielding methods will be undertaken. The test loop for the study of radiation effects at cryogenic temperatures will be designed, fabrication will be started, and preliminary tests will be run.

In the fiscal year 1961 the first conversion system tests will be run as part of the nuclear electric system (SNAP–8) development program. Much of the fundamental data required for the design of components of a high-power, high-temperature system should be completed so that early applied research design and experimental studies should be initiated on critical components of such systems. In the nuclear heat transfer rocket program, it is planned to develop the turbopump to full rated performance for use in higher power reactor tests than those considered in the fiscal year 1960 pump development. Work will be expanded on the other nonnuclear components that will be required in the nuclear rocket system.

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Advanced technical development:			
Nuclear heat transfer rockets:			
Reactor test (Rover) support	$1,910,496	$3,000,000	$4,300,000
Applied research on nuclear rockets	1,100,000	1,100,000	1,000,000
Breadboard engine design			200,000
Total	3,010,496	4,100,000	5,500,000
Nuclear electric power generating systems:			
SNAP–8 development	600,000	1,000,000	2,000,000
Applied research on high power systems	200,000	900,000	2,500,000
Total	800,000	1,900,000	4,500,000
Grand total	3,810,496	6,000,000	10,000,000

OBJECTIVE

This program covers the two principal types of nuclear systems that are considered suitable for the propulsion of high-payload rocket systems in space—the nuclear heat transfer rocket system and the nuclear electric power generating system. A description of the elements of this program follows:

NUCLEAR HEAT TRANSFER ROCKET SYSTEM

Reactor test (Rover) support

The NASA has the responsibility for supplying and developing certain nonnuclear hardware for the AEC nuclear rocket reactor program. In general, this nonnuclear hardware is equipment that is required in nuclear rocket flight systems. In addition, the NASA is responsible for supplying all nuclear rocket test facilities with the liquid hydrogen and other propellants that are required. The reactor test support items are listed below:

Pump development.—A liquid hydrogen pump is being developed for use in the reactor test program to pump hydrogen from the storage tank into the reactor during the test program. Such a pump is also required in rocket flight systems.

Turbopump system development.—The liquid hydrogen pump mentioned above will be developed to its full rated flow and pressure capability. A turbine and a gas generator will be developed to drive this pump. This system will be installed in the AEC reactor test facility for evaluation of reactor performance when combined with the characteristics of a turbopump hydrogen-propellant feed system.

Liquid hydrogen cooled jet nozzle.—A liquid hydrogen-cooled jet nozzle is required for the AEC reactor test program to evaluate the effect of regenerative cooling on reactor operation. In addition, the heat load on a nuclear reactor rocket jet nozzle is so great at the conditions that will be run that hydrogen cooling is necessary if reactor testing is to be possible. This item covers the cost of developing a suitable hydrogen-cooled nozzle and of conducting the necessary advanced work at higher temperatures than those that will be encountered in the early tests.

Liquid hydrogen and propellent supply.—As mentioned above, the NASA is responsible for supplying the propellants that are required for the nuclear rocket program. At the present time, the necessary hydrogen is being supplied from Air Force facilities and the NASA has agreed to reimburse the Air Force for all of the propellant used. Hydrogen is used in the reactor tests, and in the development of all of the nonnuclear components mentioned above. In addition, nitrogen and helium are used in the various test facilities to purge the system and to precool or chill the system down so that excessive evaporation of the costly hydrogen will be avoided.

Applied research on nuclear rockets

The work covered by this line item in the NASA fiscal year 1961 budget is aimed at developing the technology that is necessary before nuclear rocket systems can be designed, built, and operated. This technology involves problems that result when the reactor and other components in the nuclear rocket are packaged closely together as they would have to be in a flight system. It includes analysis and experiments to determine and solve the problems associated with the use of hydrogen in a reactor radiation field. The items included in this research phase of the program follow:

Rocket-system dynamics.—The successful operation of a nuclear rocket system requires the analysis and development of a system to automatically control both the hydrogen flow system and the nuclear reactor. The interaction of all of the flow system and reactor components using data obtained during steady static tests of all of the components will be analyzed so that adequate control systems may be designed. These control system studies will include the analysis and design of systems for automatically starting up the rocket system, shutting it down so that the reactor does not burn up, and then restarting the reactor system so that system may accomplish useful space missions.

Mr. THOMAS. Your justification objectives are stated as follows:

To develop the components and technology required to permit the development of nuclear-powered systems to deliver large payloads to interplanetary objectives. The current emphasis in this program is on solution of the many

technological problems that now stand in the way of nuclear system development.

This will not be spent at your laboratory at Plumbrook and neither will it be spent at any of the laboratories of the Atomic Energy Commission?

Where will it be spent?

General OSTRANDER. It will be spent through one of the laboratories of the Atomic Energy Commission to develop the pump and the turbine to run the pump and nozzle and to supply the hydrogen for our tests.

Mr. THOMAS. For the reactor test for support of Project ROVER you are requesting the sum of $4.3 million; for applied research on nuclear rockets you are requesting the sum of $1 million and for the breadboard engine design you are requesting the sum of $200,000.

What became of the other $4,500,000?

Dr. DRYDEN. It is on the next page.

Mr. THOMAS. What do you mean by the next page?

Dr. DRYDEN. Page 180.

Mr. THOMAS. For applied research on high-powered systems, $2.5 million; for SNAP–8 development, $2 million; and so forth.

What does that mean? Where will that money be spent?

General OSTRANDER. This is a development of an electric power generating equipment to use in a reactor now under development by the Atomic Energy Commission, and it will be spent with industry. We now have solicited bids but we have not selected a contractor yet.

Mr. THOMAS. What firms are engaged in this type research?

Dr. DRYDEN. North American, Thompson-Ramo Woolridge, Aerojet, General Atomico, and several others.

Mr. THOMAS. This is all in addition to what the Atomic Energy Commission spends? Also this is in addition to what your own reactor bill will be.

Dr. DRYDEN. This is to take the place of the solar-cell paddles in the bigger satellites. The Atomic Energy Commission furnishes the reactor. This money furnishes the power-generating machinery. Usually a heat transfer fluid is used to transfer the heat to drive a turbine which runs an electric generator which gives you the power. That is what the SNAP–8 development system is.

Mr. RHODES. What is that for?

Mr. HORNER. To operate the radio, instrumentation, television, if you use that.

Mr. RHODES. It provides no propulsion?

Mr. HORNER. Auxiliary power.

Mr. THOMAS. Dr. von Braun said in 1969 or 1970 you might have something like that.

Dr. DRYDEN. This is internal power.

Mr. HORNER. He was speaking with reference to page 179.

Mr. THOMAS. This is not for propulsion?

Dr. DRYDEN. No.

Mr. THOMAS. Are you spending any money in that field?

Dr. DRYDEN. Yes; that is the item we just discussed.

Mr. THOMAS. With whom are you spending that money?

Dr. DRYDEN. The pump is being developed by North American.

Mr. THOMAS. $4.3 million.

General OSTRANDER. The nozzle is North American, the hydrogen is supplied by——

Mr. THOMAS. This is research on just a half dozen component parts. You have not even broken ice, have you?

Dr. DRYDEN. This work is leading toward a so-called breadboard engine—a working engine. When they get an engine that works, and they know it will work, we go out to a contractor to develop an actual engine suitable for use in flight.

Mr. THOMAS. This is the $5½ million?

Dr. DRYDEN. Yes.

Mr. THOMAS. Is this the first expenditure you made on this?

Dr. DRYDEN. Last year there was transferred some amount of money.

Mr. ULMER. $4 million last year.

Mr. THOMAS. You set up $4.1 million for 1960 and $3,010,496 million for 1959. You have not been working on that 3 years, have you?

Mr. HORNER. Yes, sir. It was going on within the Department of Defense and the AEC before NASA got into business.

Dr. DRYDEN. Actually these numbers came from Defense.

Mr. HORNER. The 1959 numbers did.

Mr. THOMAS. Is this part of the research being done out in Ohio for the Atomic Energy Commission?

Dr. DRYDEN. No.

Mr. THOMAS. This is a separate and distinct proposition?

Dr. DRYDEN. That is right.

Mr. THOMAS. This is purely a rocket engine?

Dr. DRYDEN. Yes, sir.

Mr. THOMAS. You cover the waterfront here. Are there any other sources of power known?

SPACE POWER TECHNOLOGY

Dr. DRYDEN. Yes; there are one or two speculative ones but we are not ready to work on them seriously. One proposes to interact in some way with the magnetic field. I do not quite know how this will operate. The other is to use the solar wind—to use radiation pressure from the sun.

Mr. THOMAS. Off the record.

(Discussion held off the record.)

Mr. THOMAS. What is the nature of this?

Dr. DRYDEN. This is broken down on the pages following 182–4.

Mr. THOMAS. Insert page 182–4 in the record.

(The page referred to follows:)

Item	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Projects on space propulsion:			
Development of propellent feed system components for plasma rocket engines			$300,000
Development of ion engine system components			900,000
Plasma acceleration engine research and development			600,000
Projects on auxiliary power units:			
Research and development on thermal energy storage		$170,000	
Solar collector research		30,000	
Solar-thermionic power systems research and development		300,000	900,000
Research and development on silicon cell (solar battery) arrays		300,000	300,000
Research and development on electrolytically regenerated fuel cells		200,000	500,000
Hydrogen-oxygen fuel cell development			500,000
Studies, research and development of solar power conversion and sun-orientation systems		914,000	400,000
Total		1,914,000	4,400,000

SOLAR AUXILIARY POWER UNIT DEVELOPMENT

Three-kilowatt solar auxiliary power unit (Sunflower I).—The objective of this project is to develop a reliable electrical power supply based on solar energy for general purpose usage in satellites and space probes of the CENTAUR and SATURN class for missions in the time period 1963–68.

SOLAR POWER

Mr. THOMAS. With whom do you spend this $4,400,000 against $1,914,000 of last year?

General OSTRANDER. Let me check that.

Mr. THOMAS. The objective of this project is to develop a reliable electrical power device. This is for general purpose use in satellites.

If you get it in satellites you are liable to have it on farms, are you not?

Dr. DRYDEN. It might be a little expensive for farmers, I would guess.

Mr. THOMAS. It would be cheap power. The device will cost a lot but the power will be cheap.

Dr. DRYDEN. Will you look at the $2,100,000?

Mr. THOMAS. Yes.

Dr. SILVERSTEIN. That is a design for which we are currently contracting.

Mr. THOMAS. Could you not cut out every third one of these? You can get down to the hard core, get the payloads up in the air and cut out some of this experimentation. Let us digest a little bit at a time.

Dr. SILVERSTEIN. This is an advanced system. If you are trying to develop an automobile you can develop the brakes, the wheels, and the engine, but if you had no carburetor you could not ride the automobile.

We are trying to build a program which has enough of the elements in it so we have——

Mr. THOMAS. You want to find out all about it in 3 years.

Suppose when you die in the next 40 or 50 years these young fellows have nothing more to tell you?

Dr. SILVERSTEIN. If we want to fly SATURN with a payload and we have to put power in the payload——

Mr. THOMAS. You can use one power in one instrument. You have four different experiments going on here.

Dr. SILVERSTEIN. There are leadtimes. At low powers we use solar paddles. As we get up to 3 kilowatts we will use the solar power development we have here, which will throw the sun's heat onto a boiler and into an engine.

Up to 30 kilowatts we use nuclear power.

The nuclear power is leadtime, we know.

Mr. THOMAS. Do you need all these vehicles you have here? You have shown what you have developed until Dr. von Braun and the others get the big ones in. These are little popcorn poppers.

DELTA SPACE FLIGHT VEHICLE

Insert pages 186 through 188.

(The pages referred to follow:)

DELTA

Fiscal year 1959	$12,927,417
Fiscal year 1960	13,300,000
Fiscal year 1961	12,500,000

1. Objectives

To provide a reliable space flight vehicle for medium payload satellites and small payload space probes, replacing the present THOR-ABLE, JUNO II, JUPITER C, and VANGUARD vehicles.

2. Justification

Space projects to date have utilized vehicles that have been adapted from military ballistic missile boosters. While providing valuable interim service, most of these vehicles suffer from technical limitations that restrict their desirability for long-term application as space vehicles.

The DELTA space flight vehicle will replace the small-payload vehicles currently in use. It will be similar to the THOR-ABLE, but will have a coast-phase attitude control system, permitting higher injection altitudes. DELTA will be a three-stage vehicle in which the first stage will consist of a production THOR missile with the nose cone and guidance unit removed. The second stage will consist essentially of the second stage used in VANGUARD and THOR-ABLE with an improved radioinertial guidance system of higher accuracy. The third stage will be a solid propellant rocket motor developed for VANGUARD.

The DELTA vehicle will be applied to a number of satellites and space probe projects. It will have a payload capacity of 300 to 500 pounds for satellite applications and up to 65 pounds for probe shots to the vicinity of the moon. Delta will be useful for both inclined and polar orbits and will be launched from both the Atlantic and the Pacific Missile Ranges. Requirements for greater lunar payload capability and for increased accuracy in achieving close tolerances for orbital circularity, and special demands for obtaining attitude stabilization of certain payloads, have all combined to dictate more stringent design limits on the vehicle. In the fiscal year 1961, funds will be expended to develop hardware intended to yield more precise and controllable flight paths and velocities while at the same time increasing payload weight capacity and attitude orientation.

3. Program phasing

The DELTA program is divided into five parts: the fabrication and test of the modified VANGUARD/THOR-ABLE second stage; the procurement and test of the guidance system; the modification of the THOR boosters; the integration of the complete DELTA; and the preparation and launch.

Incremental funding for this program, including the procurement of 12 vehicles, was initiated during the fiscal year 1959. All phases of the vehicle engineering program have proceeded on schedule.

Funding for the fiscal year 1960 and beyond is required for the planned continuation of the initial contract. Specific sums proposed for obligation in a

given fiscal year are not associated with particular vehicles. However, the fiscal year 1960 funding essentially supports hardware fabrication and flight operation costs for east coast launchings; and the fiscal year 1961 funding will support similar operations from the west coast and will also initiate the vehicle improvement program to increase reliability, accuracy, and performance.

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Flight research program:			
Vehicle engineering and manufacturing, ground service equipment, and trajectory computations	$12,927,417	$11,645,000	$9,000,000
Range and launching services, shipping costs		1,655,000	2,300,000
Vehicle reliability improvements and modifications			1,200,000
Total	12,927,417	13,300,000	12,500,000

Mr. THOMAS. Who is doing this research?

General OSTRANDER. Douglas Aircraft.

Mr. THOMAS. How long have they been working on it?

General OSTRANDER. Started in 1958, I believe, or 1959.

Mr. THOMAS. You have already spent about $40 million. When will he finish this?

General OSTRANDER. The funding we have this year will complete the program.

Mr. THOMAS. You mean you will get 12 vehicles for this, General?

General OSTRANDER. That is right.

Mr. THOMAS. There is no money for VEGA?

Dr. DRYDEN. No; it has been canceled out.

VEGA SPACE FLIGHT VEHICLE

Mr. THOMAS. Insert pages 189 and 190.

(The pages referred to follow:)

VEGA

Fiscal year 1959	$14,291,494
Fiscal year 1960	4,000,000
Fiscal year 1961	----------

1. Objectives

The objective was to provide the first general purpose space vehicles in the national space vehicle program. The VEGA project was terminated on December 11, 1959, to reduce the number of rocket vehicles used in the U.S. space program. Other rocket vehicles in the national inventory will be used to accomplish the satellite and space probe projects for which the VEGA had been planned.

2. Justification

The VEGA project included a two-stage and a three-stage vehicle system. In both, the first stage used the Convair ATLAS and the second stage, a General Electric engine. The GE engine, originally used as the primary booster of the VANGUARD, was being modified to include altitude start and restart capability. The third stage used the 6,000-pound-thrust storable fuel engine currently under development by NASA's Jet Propulsion Laboratory. This particular engine will be continued as an advanced development for use in large spacecraft of the future. It is also expected that some of the material and components developed by Convair will be usable in the CENTAUR program.

3. Program phasing

During the fiscal year 1959, incrementally funded contracts were let for the design, development, fabrication and testing, and launching of eight VEGA

vehicles, including the requisite modification to the ATLAS first-stage and the development of the VEGA second-stage powerplant.

During the fiscal year 1960 the preliminary design of the second stage, the construction of a captive test article, and the development of the second-stage engine were continued. The construction of flight engines and vehicles was also initiated.

The VEGA project was terminated on December 11, 1959.

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Flight research program:			
2d-stage development, fabrication, and testing	$11,290,000	[1] $1,580,000	
3d-stage, development, fabrication, and testing	3,001,494	[1] 2,420,000	
Total	14,291,494	4,000,000	

[1] Including termination costs.

Mr. THOMAS. VEGA is canceled out.

How much money did you spend on VEGA?

General OSTRANDER. It looks like something about $18 million.

Mr. THOMAS. You will let it go down the drain?

General OSTRANDER. That is the end of it.

Mr. THOMAS. What did you have set up for it last year?

General OSTRANDER. In 1960 we had about $40 million.

Mr. THOMAS. We have been using a figure of about $18 million. Anyway, it is down the drain.

CENTAUR SPACE FLIGHT VEHICLE

CENTAUR, $47 million against $37 million to develop a general purpose flight vehicle. We have covered this before.

Where are you spending the money?

Insert pages 191 and 192.

(The pages referred to follow:)

CENTAUR

Fiscal year 1959	$4,000,000
Fiscal year 1960	37,000,000
Fiscal year 1961	47,000,000

1. Objectives

To develop a general purpose space flight vehicle employing a high-energy fuel in an upper stage.

2. Justification

CENTAUR is a two-stage vehicle whose first stage is a modified ATLAS D missile. The modification consists of replacing the cone frustum part of the forward liquid oxygen tank with a cylindrical section having the same diameter as the rest of the ATLAS. Between the lower and upper stages is a structural adapter that is attached permanently to the lower stage. The upper stage is mounted on top of the adapter which is jettisoned with the modified ATLAS booster. Sets of hydrogen peroxide rockets are utilized for upper stage attitude control during the coast period. The significant feature of CENTAUR is the use of liquid hydrogen as a fuel, thus providing a launch vehicle of much greater capability than previously available.

The CENTAUR project was transferred from ARPA to NASA on July 1, 1959. Technical direction is by an Air Force team located at the Air Force Ballistic Missile Division and reporting directly to NASA headquarters.

3. Program phasing

The CENTAUR missions will involve placing communications satellites in a stationary 24-hour orbit, and lunar and planetary probes. The first six developmental vehicles will be used for both vehicle systems tests and for payload missions.

During the fiscal year 1959 the Air Force let incrementally funded contracts for the development of the CENTAUR engines, for the development and fabrication of the CENTAUR second stages, and for the modification of the ATLAS boosters.

The existing contracts will be continued under NASA funding during the fiscal years 1960 and 1961. During the fiscal year 1960 static tests of the complete CENTAUR powerplant will be run and preliminary design will be completed on the second stage. Tests will be initiated to simulate zero-g conditions on the liquid gas tank during coasting flight.

The final design of the CENTAUR powerplant and second stage will be completed and the flight test program will be started during the fiscal year 1961.

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Flight research program:			
Procurement of booster vehicles	$4,000,000		$6,500,000
Development and procurement of second stage and engine		$37,000,000	39,500,000
Launching operations			1,000,000
Total	4,000,000	37,000,000	47,000,000

Mr. HORNER. Convair Division of General Dynamics at San Diego and Pratt & Whitney.

Mr. THOMAS. Will this complete it?

Dr. DRYDEN. This will not complete it.

Mr. HORNER. The CENTAUR vehicle will be a continuing procurement program as we buy vehicles in the coming years to support the payloads.

Mr. THOMAS. You are still on research and development on CENTAUR. When you get a completed vehicle what will it cost you? You will have spent $90 million through 1961.

Dr. DRYDEN. Research and development plus six vehicles.

Mr. THOMAS. Will this wrap it up?

General OSTRANDER. No, sir. Total cost of the program for the six vehicles, including vehicles and R. & D., will run about $130 million.

Mr. THOMAS. That means you will have to go another $40 million in 1962?

General OSTRANDER. Thereabouts.

Mr. THOMAS. When will it be ready and completed?

General OSTRANDER. First flight in the second quarter of 1961 and the last will be required in second quarter of 1962.

SATURN MULTISTAGE LAUNCHING VEHICLE

Mr. THOMAS. The SATURN program, $134 million against $55 million. The SATURN first stage is propelled by a cluster of eight.

Dr. von Braun went into this theory with us. What will this cost you?

Insert pages 193, 194, and 194–1 in the record.

(The pages referred to follow:)

SATURN

Fiscal year 1959	[1] ($19,325,020)
Fiscal year 1960	[1] (55,182,980)
Fiscal year 1961	134,308,000

[1] Funded by the Department of Defense.

1. Objectives

To develop a multistage launching vehicle for various advanced space-flight missions.

2. Justification

The SATURN program comprises a series of multistage launching vehicles of increasing payload capability for performing various space-flight missions. Minimum requirements for three important missions are: (1) to send large payloads to the Moon and near planets; (2) to place several tons of payload in a 24-hour equatorial orbit; and (3) to place a manned spacecraft (such as DYNA-SOAR) in an Earth orbit. The first version of SATURN is designed to meet these requirements. Succeeding SATURN vehicles will have greatly increased capabilities for all three of the missions previously mentioned. The increased capability is to be obtained by using upper stages from the early versions as building blocks in the final vehicle, thus minimizing the number of new stages that have to be developed. The SATURN'S first stage is propelled by a cluster of eight ICBM-type engines which deliver a total thrust of 1½ million pounds. The final version of SATURN will use uprated engines giving a thrust of at least 2 million pounds. The first SATURN vehicle will be a three-stage rocket; the final version may have five stages. Launching of the first SATURN booster with dummy upper stages is scheduled for the latter half of 1961.

The SATURN project was initiated on August 15, 1958, by an order from the Advanced Research Project Agency to the Army Ordnance Missile Command. The project was funded in the fiscal years 1959 and 1960 by ARPA. The President of the United States, on November 2, 1959, announced his intention to transfer the SATURN project to NASA. In anticipation of the transfer, NASA and the Department of Defense have established an interim working agreement that provides for immediate assumption by NASA of the responsibilities for the technical management of the SATURN vehicle development.

3. Program phasing

During the fiscal year 1959 the design of the first-stage booster and the design of tooling for the first-stage clustered tanks were initiated.

During the fiscal year 1960 the design and development of the first-stage booster was undertaken. Construction of prototype tankage proceeded, and individual engines were delivered for test. A captive firing of the eight-engine cluster is scheduled for the latter half of fiscal year 1960. Contracts for upper-stage engines and vehicles will have been let before the end of fiscal year 1960.

The fiscal year 1961 funds will provide for the continued development, construction, and testing of the first-stage booster tanks and engines. In addition, design and development of upper stages, initiated in the fiscal year 1960, will be continued. Part of the fiscal year 1961 funds will provide for the development of vehicle-borne guidance, controls and instrumentation, and the development of ground-service equipment.

4. Program costs

	Fiscal year 1959	Fiscal year 1960	Fiscal year 1961
Flight-research program:			
Development and fabrication of first-stage boosters			$57,500,000
Development and fabrication of upper stages			42,300,000
Guidance, controls, and instrumentation			12,800,000
Ground-service equipment			9,708,000
Direct material			12,000,000
Total	[1] ($19,325,029)	[1] ($55,182,980)	134,308,000

[1] Funded by the Department of Defense.

SATURN

OBJECTIVES

This program, which has been assigned the highest national priority, is designed to provide a multistage vehicle of high payload carrying capability coupled with a substantial growth potential. The mission objectives of the early version SATURN are as follows:

1. To send large payloads to the Moon and near planets.
2. To place several tons of payload in a 24-hour equatorial orbit.
3. To place a manned spacecraft in an Earth orbit.

The requirement for developing a vehicle of the magnitude of SATURN is based upon the objective of flying much larger payload missions than can be handled by presently available vehicles.

Development of the SATURN vehicle is proceeding through an orderly schedule of ground and flight tests. Captive ground tests are scheduled in the fiscal year 1960; a development flight test program consisting of at least 10 vehicles will start in the fiscal year 1961; and the first operational flight is planned for the first quarter of the fiscal year 1964. Technical direction of this program is at the NASA Huntsville facility.

DEVELOPMENT AND FABRICATION OF FIRST-STAGE BOOSTERS

By the beginning of the fiscal year 1961, the final assembly of the first SATURN flight test vehicle (SA–1) will have been started. The initial nonflyable booster (SA–T) will have completed its first firing test at Huntsville.

Mr. THOMAS. Off the record.

(Discussion held off the record.)

Mr. THOMAS. The cost is $850 million. Is that correct?

Mr. HORNER. About right.

Mr. THOMAS. We have appropriated how much to date? It will cost $850 million, and ready in early 1964?

General OSTRANDER. In 1964.

Mr. THOMAS. What have we spent to date and when did we start this? Did we start in 1959?

General OSTRANDER. 1958.

Mr. THOMAS. What did we spend in 1958, 1959, 1960 and what will it be in 1961? Going through 1961 you will have spent about $208 million?

Dr. DRYDEN. That figure covers only the outside contracting for SATURN. There is in addition our costs under S. & E., C. & E., and support of plant under R. & D.

Mr. THOMAS. This is the outside contracting cost?

Dr. DRYDEN. Under R. & D., that is right.

Mr. THOMAS. This does not take care of the Huntsville cost?

Dr. DRYDEN. That is right.

Mr. THOMAS. This is the outside contracting cost?

Dr. DRYDEN. The 1961 figure for Huntsville is $58.3 million for S. & E., $18.7 million for support of plant, R. & D., and $26.7 million for C. & E., a total of $103.7 million.

Mr. THOMAS. What was the 1959 cost?

Dr. DRYDEN. The comparable 1959 figure was about $8 million. Through fiscal 1961 the total will be about $340 million on SATURN.

Mr. THOMAS. That is contract cost and Huntsville cost?

Dr. DRYDEN. That is right.

Tracking and Data Acquisition

Mr. Thomas. Insert pages 195 through 199 in the record.
(The pages referred to follow:)

Tracking and Data Acquisition

Fiscal year 1959	$3, 095, 674
Fiscal year 1960	16, 266, 000
Fiscal year 1961	32, 550, 000

1. Objectives

To operate tracking and data acquisition facilities necessary to support the overall NASA space flight program; to provide tracking and data acquisition support for space flight operations upon request by other Government agencies; and to provide for research and development on improved tracking and data acquisition systems and equipment. Major technical objectives included in fiscal year 1961 program are:

(*a*) Improvement of the overall accuracy and efficiency of existing NASA tracking stations.

(*b*) Development of a prototype electronic tracking system of inherently greater precision than any present system.

(*c*) Development of communications techniques for spacecraft at planetary distances.

(*d*) Speedup of data handling to reduce time lag between the experiment and the conclusions.

(*e*) Development of special trajectory measuring techniques and systems for complex payloads.

2. Justification

In all cases of space flight operations, whether a scientific satellite, a space probe, a sounding rocket, or a manned vehicle, there is a need for tracking units capable of delivering orbital data or position time histories, and a need for telemeter receivers for data acquisition. These devices must be properly coordinated by communications links to permit the data to be transmitted to a suitable computing center, where it may be rapidly reduced to a form in which it can be studied and analyzed by the scientists. The data represents the raw material from which the scientific experimenters will gain their new knowledge of space. The quantity and quality of this raw material will determine the progress made in space research.

While the NASA network of stations is designed to afford the maximum amount of operational flexibility, there are special conditions associated with each test which may require equipment modifications, or in certain cases, the temporary installation of new items of equipment at new tracking locations.

In order to minimize the requirements for new stations, or to compensate for temporary deficiencies, the NASA proposes to provide support to cooperating non-NASA stations which are suitably equipped to perform a useful function for the purposes of a particular experiment.

ADVANCED TECHNICAL DEVELOPMENT

Tracking and data acquisition systems development.—A continuing effort must be maintained to advance the state of the art in tracking systems and methods, in data reduction and analysis techniques, and in methods of telemetry and data transmission. Specific areas of basic research include theoretical studies and experimental verifications of the effects of propagation delays on various transmissions of time signals since accurate time measurement to within a fraction of a second is necessary in refined calculations of orbits; theoretical and applied research in low noise preamplifiers to improve reception of faint radio signals; theoretical studies and analysis of improved orbital computation methods; and studies into techniques for communication with space vehicles at planetary distances.

In addition, development of refinements in the measuring capabilities of present minitrack systems is contemplated to meet more exacting requirements. Included are the development of such items as a rubidium-vapor, frequency-standard equipment to improve calibration accuracy; precision propagation delay measurement equipment; onsite data reduction systems; and prototype calibration equipment to calibrate tracking systems.

The development of new types of tracking and data acquisition equipment is proposed which will have more accuracy than present systems. This work will include new antenna systems and receivers to operate at higher frequencies (2,000 megacycles); transmitters for range determination; self-tracking systems for directional antennas; any payload beacons for use in conjunction with the ground systems.

Computer support programs.—Studies will be undertaken to determine the best modulation technique for data acquisition and for the adaptability of the data received to computer programs for reducing the data. Consultative services will be used in this research effort.

Data systems development.—Work will be continued in this area to foster the development of automatic data reduction techniques as well as to improve the data reduction on data now being received from telemetry systems operating in satellites in orbit.

Optical systems development.—It is proposed to improve the present capability in this basic method of tracking especially for geodetic programs. Improvements are necessary in the timing system and in the methods of reducing data from photographic film accurately and rapidly. Electronic-optical techniques will be investigated to marry the advantages of electronics and optics into an improved system for tracking optically. Other work will include star cataloging, application of optical tracking to lunar or deep-space vehicles, exploration of possible uses of optical telemetry, improvements in image converters, and photodetectors, and the use of light reflectors on payloads.

MERCURY tracking net techniques.—The MERCURY tracking net will undergo continuing refinement and improvement to insure maximum effectiveness and reliability. Work will continue on data error analysis, telemetry systems, tracking techniques, and communications as applied to manned space flight. The use of contract consultants are relied on heavily in this work.

Development of high gain antennas.—Many long-range problems are involved in developing equipment to meet the requirements of communicating with vehicles at distances of millions of miles. While payload power is expected to increase, it will still be necessary to improve the antennas and receivers on the ground. In this connection it will be necessary to do considerable research and development to design and develop techniques and systems to economically improve upon present large antenna systems to receive relatively faint signals.

Trajectory measurement and command equipment.—Special types of equipment are needed for vehicles whose controlled trajectory go well beyond the range of established launching ranges. The type of equipment required will depend on the characteristics of the payload and what command control functions are involved. Certain vehicles will have capability for stopping and starting powered flight in last engine stages. To control the operation of such stages at remote locations will require development of special trajectory measurement and command control equipment.

FLIGHT RESEARCH PROGRAM

Operation of satellite ("minitrack") stations.—During the fiscal year 1961 there will be 14 minitrack operating stations, including 4 new ones being installed during the fiscal year 1960. These stations employ radio interferometers and are used primarily for tracking satellites which send out radio signals, where precise real-time date is not required. They have all-weather capability. They cannot track passive satellites (noes which do not emit signals) nor can they provide the precise orbit data available from optical systems. They have the advantage of being able to detect the angular direction of a satellite with respect to the station without prior information as to precisely where to look. These stations must be located in areas free of extraneous electrical disturbances. From a number of observations from different stations, a reasonable orbital determination can be made.

Each minitrack station receives and records telemetry data on magnetic tape. Data from these stations are fed to a central control, communications, and computing center at the Goddard Center. Automatic data read-out equipment is being provided to speed up data collection and to permit tracking a greater number of satellites.

The operational cost of three microlock stations is included in the 1961 estimates. These stations will be managed by the technical personnel that manage

the minitrack stations. The microlock stations may eventually be integrated into the minitrack net at common locations with the minitrack stations.

Operation of optical tracking stations.—The existing 12 Baker-Nunn optical stations will continue in operation during the fiscal years 1960 and 1961 under the technical and administrative direction of the Smithsonian Astrophysical Observatory.

The optical stations can photograph relatively faint space objects (satellites) against star backgrounds to provide a precise determination of the angular position of the object. Observations can only be made when the visability is good and by virtue of sunlight reflected from the object. Therefore, observations can only be made in periods of clear twilight. Moreover, the camera can only see a small segment of the sky at a time, and it must have a prior knowledge of where to look or the satellite will pass out of range before the camera can search any appreciable segment of the sky. Information on where to look is usually obtained from minitrack or similar electronic systems which do not have the acquisition limitations of optical systems.

It is theoretically possible from three or more optical observations to obtain the most precise orbital data of any technique known. For certain geophysical experiments, such as in geodetic and air drag experiments, the maximum precision of optical techniques is necessary. The optical stations must be located at sites where the weather conditions are such that good visibility generally prevails. This site limitation is not necessarily compatible with the site locations of electronic systems, which have other criteria governing their best location.

Included in the cost of operating the optical stations is the cost of data transmission, data reduction, and data interpretation which is performed by the Smithsonian Astrophysical Observatory at Cambridge, Mass. Funds are included for the cost of the Moonwatch teams which are volunteer groups assisting the Smithsonian Astrophysical Observatory in securing observations of satellites at different places in the world, using simple telescope equipment. The compensation to the Moonwatch teams merely defrays expenses for materials and for certain items of equipment. There is no compensation for the volunteer services as such.

Operation of the deep space network.—During the fiscal year 1961 it is expected that three stations will be operational. The JPL station at Goldstone, Calif., is currently operational; the Woomera, Australia, station will be added during the fiscal year 1960; and the South Africa station will be completed during the fiscal year 1961.

Mr. THOMAS. This is to operate the tracking data facilities necessary to support the overall flight program. You are erecting some new stations. We went into this in some detail. This is all by contract. The other part of the budget shows where you are erecting some new ones.

Dr. DRYDEN. And we are to furnish the details of some of these operating costs to you.

Mr. THOMAS. Who are the operators? How many are involved? Is it the same number we had in construction?

Dr. DRYDEN. The same people. We were talking about the operating costs. We will make up a table for you.

(The information is to be found on page 332.)

Mr. THOMAS. Mr. Boland?

Mr. BOLAND. No questions.

Mr. THOMAS. Mr. Jonas?

Mr. JONAS. No questions.

Mr. THOMAS. Thank you, gentlemen.

I humbly apologize for keeping you so late. We have covered a lot of ground in 3 days, however.

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